Institute for a Secure & Sustainable Environment

2018-2019 Annual Report to THEC

ISSE Mission Statement

The University of Tennessee's Institute for a Secure and Sustainable Environment (ISSE) seeks to promote the development of policies, technologies, and educational programs that cut across multiple disciplines, engage the university's research faculty and staff, and grow in response to pressing environmental and security issues facing the state, the nation, and the globe.

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Contact ISSE

ISSE Main Office
Phone: 865-974-4251
Fax: 865-974-1838
Email: isse@utk.edu

Dr. Mingzhou Jin, Director
Phone: 865-974-1843 or 974-9992
Email: jin@utk.edu

Message from the Director

I am proud to present this report of the Institute for a Secure & Sustainable Environment's accomplishments and achievements for 2018–2019. We have made great strides in education, research, and technology transfer this year, as evidenced by the number of publications and presentations by faculty and students, as well as several innovative products of their research. While all our accomplishments are worthy of note, I would like to highlight a few here.

ISSE has been involved in several programs that should improve community engagement. In partnership with the Appalachian Regional Commission, Dr. Tim Ezzell and Catherine Wilt teamed up with Katie Cahill at the Baker Center to create the Appalachian Leadership Institute. The Institute promotes leadership in the Appalachian Region to improve its social, environmental, and economic sustainability. As part of the Appalachian Community Technical Assistance and Training (ACTAT) Program, ISSE researchers are working with West Virginia University's National Environmental Services Center and the University of Kentucky's Water Resources Research Institute to provide technical assistance for water services to small communities in rural Appalachia.

ISSE is committed to sustainability education and supported 21 graduate and 19 undergraduate students this year. TNWRRC offered nine courses this year and trained 2,979 professionals in these workshops. Tennessee Erosion Prevention and Sediment Control (TNEPSC) courses were developed and offered in collaboration with the Tennessee Department of Environment & Conservation (TDEC).

ISSE received multiple NSF grants this year. With Dr. Andrew Muhammad of UT's Institute of Agriculture's (UTIA), ISSE received a four-year grant from the NSF's Innovations in Food, Energy, and Water Systems program for a project to advance modeling methodologies and improve understanding of the global crop supply chains. ISSE's Methane Center received an NSF award to study environmental implications of biocides used in hydraulic fracturing.

This past year, ISSE enhanced its collaborations with TDEC, Tennessee Department of Transportation, Tennessee Valley Authority, and Oak Ridge National Laboratory. TDEC awarded almost $9 million in grants to Tennessee school districts to replace diesel buses with alternative fuel buses with the help of East Tennessee Clean Fuels (ETCF). In conjunction with TDOT and TDEC, ETCF developed the Tennessee Green Fleets Certification Program. US Geological Survey (USGS) recognized Green Fleets's performance-based metrics to analyze vehicle and fuel-use data. TVA has contributed to an ETCF staff position for the DriveElectricTN (DET) initiative. The funding will allow ETCF to build a membership program to make the DET initiative self-sustaining and scalable. ISSE faculty worked closely with ORNL on projects for modeling and controlling imbalanced loads in a residential microgrid, for studying policies that promote alternative fuel vehicles, and for better landfill waste management.

This highly productive year is the result of the combined visions and efforts of many, many people. Because of these tireless contributors and supporters, ISSE has realized several of its dreams and laid foundations for new growth and innovation, not only in our region but also in the wider world.

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Executive Summary

During 2018-19, ISSE continued to expand its research and outreach, and this report describes the activities carried out by ISSE staff, students, and ISSE-affiliated faculty.

ISSE has a robust internal operation with 15 staff and five faculty members plus five interns and six visiting scholars. Our 14 affiliated faculty members represent the departments of Ecology & Evolutionary Biology, Biosystems Engineering & Soil Science, Sociology, Economics/Baker Center for Public Policy, Civil & Environmental Engineering, and Industrial & Systems Engineering; our seven advisory board members come from UTK, UTIA, ORNL, TVA, and TDEC.

Each ISSE program has conducted significant research: water resources through four US Geological Survey projects; methane hydrates and global soil moisture datasets; ways to establish a US-China transdisciplinary research coordination network for identifying grand challenges at the nexus of food-energy-water systems (FEWS); and trends in Appalachian tourism and diversity. ISSE research projects have engaged more than 50 UT faculty members, one postdoc, 23 graduate students, and 19 undergraduate students.

ISSE awarded four new seed projects in FY19. This year's awards support research projects related to sustainability, especially projects related to water, energy, and food sustainability that have potential for external funding opportunities. ISSE's external funding sponsors include DOE, UT-Battelle/ORNL, USGS, Appalachian Regional Commission (ARC), National Parks Service (NPS), and National Science Foundation (NSF).

Besides a healthy list of conference presentations and publications—most in peer-reviewed journals—ISSE's work has received extensive media coverage, transferred knowledge and information through a variety of programs and activities, created and shared large datasets, and fostered international exchanges. Many ISSE faculty have been recognized by their peers with honors and awards.

ISSE has increased its training and education programs with new courses and an expanding base of participants across the state. Our programs are discussed in detail beginning on page 27.

While ISSE's efforts in outreach and collaboration reached into many sectors within our state and region, it is interesting to note Dr. Tim Ezzell's grant from the Getty Foundation to create the UT Campus Heritage Plan; the purpose is to inventory and document UT's historic assets. In 2019, he photo-documented Knoxville's Eugenia Williams House, a building of historical significance to UTK, celebrated for its design quality and workmanship.

ISSE Centers & Programs

The Institute for a Secure & Sustainable Environment was established as a Center of Excellence by the Tennessee Higher Education Commission in April 2006, as the result of a review, reorganization, and renaming of the previous Center of Excellence, Waste Management Research and Education Institute (established in 1985). Following are the current programs housed in ISSE.

Centers

China-US Joint Research Center for Ecological and Environmental Change (JRCEEC)–FEWSTERN

JRCEEC addresses the combined effects of climate change and human activities on regional and global ecosystems and explores technologies to restore degraded environments. Its mission is to organize and implement international scientific and engineering research; serve as a center for scientific information exchange; and provide international education and technical training. Cooperative mechanisms to achieve these goals include joint research projects, academic exchanges, student education, and technical transfer and training. Dr. Jie (Joe) Zhuang coordinates the center and is a Research Professor in the UTIA Department of Biosystems Engineering & Soil Sciences.

East Tennessee Clean Fuels (ETCF)

ETCF works to increase the use of cleaner American fuels and vehicles and energy saving transportation technologies to improve air quality and health, curb dependence on imported petroleum, and support Tennessee's economy. Its mission is to implement alternative fuel projects in East Tennessee and to make ETCF a sustainable coalition of involved participants from across East Tennessee. ETCF is a 501(c)3 under the umbrella of Transportation Energy Partners. Mr. Jonathan Overly is the Executive Director and Coordinator.

Methane Center

The Methane Center integrates science, engineering, and business models to create a broad conceptual understanding of CH_4 (methane) as a driver of ecosystem processes and services. Center researchers use this understanding to create a lifecycle assessment framework for environmentally sustainable generation, management, and utilization of CH_4. The center's mission is to provide fundamental and technological research advances and training in CH_4 environmental science. The aim is to produce young engineers and scientists who are dedicated to effective communication of scientific findings to inform and stimulate the public and provide structured rationale for economic and environmental policy decisions and regulations. Dr. Terry Hazen directs the Methane Center.

Tennessee Water Resources Research Center (TNWRRC)

TNWRRC is a federally designated state research institute supported in part by the US Geological Survey. The center was established following enactment of the Water Resources Research Act of 1964. TNWRRC partners with the state of Tennessee as a primary resource to develop and implement programs that can achieve sustainable quantities of quality water in Tennessee and the nation. Dr. John S. Schwartz directs TNWRRC and is a professor in Civil & Environmental Engineering.

Programs and Initiatives

Appalachian Leadership Institute (ALI)

ISSE partnered with ARC to launch this program focused on the unique challenges and solutions around Appalachia's economic development. ALI trains community leaders who live and work in the region through skill-building seminars, best-practice reviews, and field visits across the 13 states that make up the Appalachian region. The goal is to create leaders who can help the region adapt to these changes and use opportunities to create thriving, equitable, and sustainable communities. Dr. Timothy Ezzell is the PI for this program and a Research Professor in Political Science.

Worker Health and Safety Training at Department of Energy Facilities

DOE Worker Training was developed to protect and inform DOE communities and their workers by delivering quality and flexible safety and health training to target populations of hazardous waste workers and emergency responders. Its mission is to prevent work-related harm by training workers to protect themselves and their communities from exposure encountered during hazardous waste operations and transportation, environmental restoration at nuclear weapons facilities, or chemical emergency responses. Dr. Sheila Webster (retired) is the PI and Rex Short is Senior Research Associate and Trainer.

ISSE Advisory Board, Faculty & Staff

ISSE Advisory Board	
Stan D. Wullschleger	Director, Environmental Sciences Division; Director, Climate Change Science Institute, Oak Ridge National Laboratory
Xin Sun	Director, Energy & Transportation Science Division, Oak Ridge National Laboratory
Brenda Brickhouse	Vice President, Environmental and Energy Policy; TVA Chief Sustainability Officer, Tennessee Valley Authority
Kendra Abkowitz Brooks	Assistant Commissioner, Office of Policy and Sustainable Practices, Tennessee Department of Environment and Conservation
Chris Cox	Professor and Department Head, Civil and Environmental Engineering, Tickle College of Engineering, University of Tennessee, Knoxville
David White	Associate Dean for Research; Associate Director, Tennessee Agricultural Experiment Station, University of Tennessee Institute of Agriculture
Bill Dunne (as observer)	Associate Dean for Research & Facilities, Tickle College of Engineering, University of Tennessee, Knoxville

ISSE Faculty	
Mingzhou Jin	ISSE Director, Professor of Industrial & Systems Engineering and Civil & Environmental Engineering
Tim Ezzell	Director, Appalachian Leadership Institute, Assistant Research Professor
Terry Hazen	Director, Methane Center, Governor's Chair, Professor of Civil & Environmental Engineering
John Schwartz	Director, Tennessee Water Resources Research Center, Professor of Civil & Environmental Engineering
Yaoping Wang	Assistant Research Professor

ISSE Affiliated Faculty	
Paul Arnsworth	Ecology & Evolutionary Biology
Walker Forbes	Biosystems Engr & Soil Science
Joshua Fu	Civil & Environmental Engr
Jon Hathaway	Civil & Environmental Engr
Qiang He	Civil & Environmental Engr
Robert Jones	Sociology
Anahita Khojandi	Industrial & Systems Engr
Jiafu Mao	Industrial & Systems Engr
Thanos Papanicolaou	Civil & Environmental Engr
Sean Schaeffer	Biosystems Engr & Soil Science
Charles Sims	Baker Center for Public Policy, Department of Economics
Chris Wilson	Civil & Environmental Engr
Jie Zhuang	Biosystems Engr & Soil Science

ISSE Staff	
Maria Campa	Post-Doctoral Research Associate, Methane Center
Kellie Caughorn	Senior Administrative Services Assistant, Tennessee Water Resources Research Center
Tim Gangaware	Research Director, Tennessee Water Resources Research Center
Lissa Gay	ISSE Communications Director
Nawei Liu	ISSE Research Associate
Brandy Norwood	ISSE Business Manager
Jonathan Overly	Director, East Tennessee Clean Fuels
Kelly Porter	Administrative Specialist, Tennessee Water Resources Research Center
Sherry Redus	ISSE Communications Coordinator
Dylida Ries	ISSE Accounting Specialist
Rex Short	Program Manager, Technology Research and Development Program
Daniel Siksay	Coordinator, East Tennessee Clean Fuels
Katie Walberg	Research Specialist, Tennessee Water Resources Research Center
Sheila Webster	Director, Technology Research and Development Program
Catherine Wilt	ISSE Research Associate

Faculty Engaged in Sponsored Research

Project	PI, Co-PI	Sponsor
2019 International Conference on Cleaner Production and Sustainability	Mingzhou Jin, Co-PI Andrew Muhammad	US National Science Foundation
Appalachian Community Technical Assistance and Training (ACTAT) Program	Thanos Papanicolaou, Co-PIs Timothy Ganagware, Christopher Wilson	West Virginia University (WVU)
Appalachian Leadership Institute	Timothy Ezzell, Co-PIs Katie Cahill, Catherine Wilt	US - Appalachian Regional Commission
Data Analytics Support for Integrated Earth Model	Yaoping Wang, Co-PI Mingzhou Jin	DOE-ORNL-UT-Battelle-ORNL
FY 2016 Water Resources Research Institute Program (See following table for project details.)	Timothy R Gangaware, Co-PIs Joshua Fu, Jon Hathaway, Anna Szynkiewicz, Thanos Papanicolaou, Christopher Wilson	DOI - US Geological Survey
FY 2017 Water Resources Research Institute Program (See following table for project details.)	Timothy R Gangaware, Co-PIs Thanos Papanicaolou, John Schwartz, Jon Hathaway, Christopher Wilson, Achilleas Tsakiris	DOI - US Geological Survey
FY 2018 Water Resources Research Institute Program (See following table for project details.)	Thanos Papanicolaou, Co-PIs Timothy Gangaware, John Schwartz	DOI - US Geological Survey
FY 2019 Water Resources Research Act Program (See following table for project details.)	John Schwartz, Timothy Gangaware, John Buchanan, Maryam Salehi, De'Etra Young, Jon Hathaway, Larry McKay	DOI - US Geological Survey
Increasing Economic and Entrepreneurial Opportunities by Promoting Outdoor Recreation Among Underrepresented Visitor Groups	Timothy Ezzell	East Tennessee State University (ETSU)
Industrial Landfill Waste Management (Reduce, Recycle, and Reuse) Technology Assessment	Mingzhou Jin, Andrew Muhammad, Yaoping Wang	DOE-ORNL-UT-Battelle-ORNL
INFEWS: U.S.-China: Coupled FEWS Modeling for Sustainability of the Global Crop Supply Chain with a Focus on China - US Interactions	Mingzhou Jin	US National Science Foundation
Microgrid Optimization	James Ostrowski	DOE-ORNL-UT-Battelle-ORNL
Policy Study on the Adoption of Alternative Fuel Vehicles	Mingzhou Jin	DOE-ORNL-UT-Battelle-ORNL
Southern Appalachian Cooperative Ecosystems Studies Units, Characterizing Water and Soil Chemistry from the Chimney Tops 2 Fire	John Schwartz, Co-PI Qiang He	DOI - National Park Service - Great Smoky Mountains National Park
Stormwater Infrastructure Inventory and Mapping for the Town of Farragut - Phase II	Thanos Papanicolaou, Co-PIs Christopher Wilson, Timothy Gangaware	Town of Farragut
Trends and Strategies for Tourism in Appalachia	Timothy Ezzell, Co-PIs Jui-Chi Chen, Catherine Wilt	US - Appalachian Regional Commission
Vital Signs Water Quality Monitoring	John Schwartz	DOI - National Park Service - Great Smoky Mountains National Park
Worker Training at DOE facilities FY 2018	Sheila Webster	National Partnership for Environmental Technology Education
Worker Training at DOE facilities FY 2019	Sheila Webster	National Partnership for Environmental Technology Education

US Geological Survey Active Projects

Project	PI	Co-PIs
FY 2016 Water Resources Research Institute Program	***Timothy Gangaware***	***Joshua Fu, Jon Hathaway, Anna Szynkiewicz, Thanos Papanicolaou, Christopher Wilson***
Using UV/Peroxyacetic Acid to Remove Pharmaceuticals from Reclaimed Wastewater	John Buchanan	
Investigating Changes of River Course of the Tennessee River and the Impact from Regional Climate Change	Joshua Fu	Xinyi Dong
Measuring Water Table Fluctuations Under Different Irrigation Regimes in Western Tennessee Agroecosystems	Jon Hathaway	Christopher Wilson, Shawn Hawkins
Urban Stream Restoration Planning Towards Cost-Effective Mitigation of the Effects of Hydromodification	John Schwartz	Robert Wockman
Development of a Robust Model for Cross-Scale Predictions of Flow and Sediment Transport	Thanos Papanicolaou	Benjamin Abban
Environmental Impacts of Coal Ash Spill on Nutrient Cycling and Surface Water Quality in Eastern Tennessee	Anna Szynkiewicz	
FY 2017 Water Resources Research Institute Program	***Timothy Gangaware***	
Evaluation of Fecal Indicators and Pathogens at Recreational Beaches in Central Tennessee	Frank Bailey	Megan Stallard
Sediment Source Tracking in Urban Watersheds	Jon Hathaway	Thanos Papanicolaou, Christopher Wilson
Characteristics of Fine Sediment Sourcing, Sediment modelingSurface Water Quality Monitoring	John Schwartz	
Examining Sediment Rating Curve Hysteresis with State-of-the-Art Sensors	Thanos Papanicolaou	Achilleas Tsakiris, Jon Hathaway
Combined Field Study of Turbulence and Bed Morphology in Mountainous Boulder Arrayed Streams	Thanos Papanicolaou	Michah Wyssmann

pictured left to right: Alexa Voytek, TDEC Office of Energy Programs, Middle-West Tennessee Clean Fuels; Daniel Siksay, East Tennessee Clean Fuels; Tim Rayburn, UPS; Jonathan Overly, East Tennessee Clean Fuels; Tim Burchett, US Congressman, Tennessee 2nd District; Anna Schneider, Volkswagen; Joe Reisz, Agility Fuel Solutions

Project	PI	Co-PIs
FY 2018 Water Resources Research Institute Program	***Thanos Papanicolaou***	
Rethinking Bank Stabilization in Tennessee to Develop a Classification Protocol for Agricultural and Urbanized Systems	Jon Hathaway	John Schwartz, Christopher Wilson
Low-cost Real-time Stream Flow Network for Falling Water River Watershed	Alfred Kalyanapu	
Three Dimensional Modeling of River Flows Under Extreme Weather Scenarios	Jejal Bathi	Kidambi Sreenivas
FY 2019 Water Resources Research Institute Program	***John Schwartz***	***Timothy Gangaware***
Understanding Effluent Movement in Clayey Soils when using Subsurface Drip Dispersal to apply Domestic Wastewater	John Buchanan	
Investigate Industrial Facilities Storm Water Quality and SWPPP Performance	Maryam Salehi	
Harmful Algal Blooms in Critical Amphibian Habitats at Mammoth Cave National Park, Kentucky	De'Etra Young	Brittany Hogan, Tom Byl
Real-Time Adaptive Detention Control Network: An Application in the Conner Creek Catchment	Jon Hathaway	Aaron Akin
From the Plot to the Catchment Scale: Towards the Next Generation of Hydrodynamics Sediment Transport Models	Jon Hathaway	Christos Giannopoulos
Flood History from Paleoflood Deposits in Cut Bank Soil Profiles in Chickmaugua Reservoir, Tennessee River	Larry McKay	Sally Horn, Paula Perilla-Castillo

ISSE Student Highlights

Graduate Students

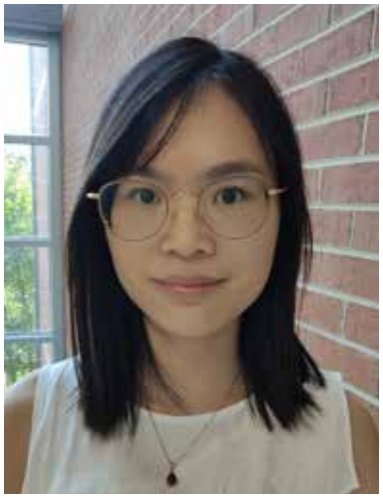
Sa'ad Abd Ar Rafie is a third year Ph.D. student in the Department of Civil and Environmental Engineering. Sa'ad is working with Drs. Terry Hazen and Sally Horn to investigate the impact of fire on interactions between the subsurface microbiome and the cycling of nutrients and carbon. His research builds on past studies that suggest methane and carbon dioxide flux of forest soils are affected by fire in part due to changes in the microbiome as well as physical disturbances impacting its capacity as an atmospheric methane sink. The systems biology approach of the research on fire-affected microbiomes builds on the Methane Center's vision to deepen the conceptual understanding of ecosystem processes for a more environmentally sustainable future.

Aubrey Fine is a third year Ph.D. student in the Plant, Environmental, and Soil Sciences degree program and the Department of Biosystems Engineering and Soil Science. Ms. Fine earned a BS in Soil, Environmental, and Atmospheric Sciences from the University of Missouri in 2012 and an M.S. in Soil Science from The Pennsylvania State University in 2015. Aubrey then worked with the Soil Health Laboratory at Cornell University where she researched multivariate statistical relationships and regional trends in a large dataset of measured soil health properties. As a doctoral student, Aubrey's research focuses on exploring soil biogeochemistry and microbial carbon cycling processes as influenced by factors including soil physical structure, viral ecology, sustainable agricultural management, and climate change. Since 2017, Ms. Fine has first-authored two peer-reviewed publications and has presented her doctoral research at several international conferences and professional meetings.

Jason R. Brown is a first year Master's student in Biosystems Engineering and Soil Science, having earned his BS in 2019. His current research examines the effects of acid rain deposition in the Great Smoky Mountains National Park including wet and dry deposition of acidic compounds and metals to soils, the resulting addition to surface waters, and the fate and behavior of organic acids within surface waterways. Mr. Brown's research interests include pollutant introductions to natural ecosystems with an emphasis on waterways, the remediation of polluted soils and waters, and research and development of monitoring and sampling technology. Mr. Brown has produced general research articles for publication to the Great Smoky Mountains National Park Fisheries Department website in addition to being a regular contributor to their periodical newsletter.

David Grant is a first year Master's student in the Department of Microbiology. David received his Bachelor of Science in the College of Arts & Sciences from UT in 2017. His current research uses molecular techniques to manipulate the genomes of specific Streptomyces strains to determine what makes certain microbial members of plant root communities competitive colonizers of plant roots. Mr. Grant's research interests include microbial genetics and genome manipulation techniques as well as understanding the chemistry behind secondary metabolites made by microbes like Streptomyces that have large metabolic profiles and the influence these products can have on plant root colonization.

Zabrenna Griffiths is a second year Ph.D. student in the Genome Science & Technology department and has recently joined the Hazen Laboratory. Building upon previous studies conducted by Dr. Hazen and members of this lab, Zabrenna plans to conduct a multiomics experiment to investigate the changes in deep ocean microbial community composition and oil-degrading genes after the addition of crude oil, both aerobically and anaerobically. She aims to increase the understanding of these biodegradation pathways to address water quality issues associated with the oil and gas industry.



Jiamei Huang is a first year Ph.D. student in the Department of Electrical Engineering & Computer Science. Jiamei received her BS and MS degrees from the College of Automation Engineering of Nanjing University of Aeronautics & Astronautics, Nanjing, China, in 2012 and 2015. Her current research focuses on water quality monitoring techniques, especially chemical oxygen demand (COD) detection. High levels of COD in water could be a threat to human health because it often correlates with contamination. Jiamei employs optical spectroscopy and headspace gas analysis to study the properties of water, in order to develop an automated and real-time monitoring method of COD levels during wastewater treatment. Her research interests include sensors, signal analysis, and integration & optimization of sensing systems.

Zaher Jarrar is a fourth year Ph.D. student in the Department of Civil and Environmental Engineering. Jarrar received his Bachelor of Science in Civil Engineering from Birzeit University, West Bank, Palestinian Authorities in 2012, and he received his Master's from the Department of Civil and Environmental Engineering in 2018. His current research focuses on understanding underlying physical processes of the emergent phenomena during gas production from hydrate-bearing sediments. Such phenomena include fines migration, fines clogging, over-pressurization, and gas-driven fractures. Mr. Jarrar conducts research in unique, in situ experiments that involve monitoring gas hydrate formation and dissociation in granular materials. His research outcomes help evaluate optimal conditions for the various gas production strategies from gas hydrate-bearing reservoirs.

Songyi Liu is a fourth year Ph.D. student in the Department of Civil and Environmental Engineering. Songyi Liu received his Bachelor of Engineering in Environmental Engineering from Beijing University of Chemical Technology, Beijing, China, in 2012. His current research focuses on Microbial Source Tracking for Detection of Fecal Contamination in Environmental Waters and Differential Decay of Fecal Indicator Bacteria Originating from different Sources. Mr. Liu's recent presentation was at the 28th Tennessee Water Resources Symposium, titled *The influence of environmental conditions on the survival of Escherichia coli originating from pavement stormwater runoff.*

Grace Medley is a second year Master of Public Policy and Administration (MPPA) student. Grace received her Bachelor of Arts, Cum Laude, in the Fall of 2018 at UT, where she double majored in Sociology and Political Science. Grace is in the Management track of the MPPA program with prior experience in procurement and city government. Grace's areas of interest include state and local government, public sector research, and non-profit administration.

Scott Satinover is a fourth year Ph.D. student in the Bredesen Center, pursuing a degree in Energy Science and Engineering. He currently works with Dr. Abhijeet Borole and Dr. Terry Hazen on Microbial Electrolysis Cells (MECs). MECs are used to convert organic materials in renewable hydrogen using a community of microbes. This community populates an electrode known as an anode, which then supplements the energy required to produce hydrogen at a secondary electrode by consuming organic materials. These devices should be more energy efficient than conventional water electrolysis to produce hydrogen while also cleaning toxic effluents from industries. He currently works on testing these devices on a number of complex waste products, including wastes from pyrolysis, fermentation effluent, hydrothermal liquifaction, ground water, and oil and gas waste water. He wants to understand general characteristics on MEC performance as a function of feedstock and hopes to aid in the acceleration of this technology in order to contribute to a renewable energy operated economy. Scott has published more than 20 articles in the Daily Beacon through the *Ask a Scientist* column and has been invited to give talks to the local chapter of the nonprofit, *Taste of Science*.

Salley Reamer is a second year Master's student in the Department of Civil & Environmental Engineering with a focus in Water Resources. Salley earned her Bachelor's of Science in Environmental Engineering from Clemson University in 2018. Salley's current research is analyzing the impacts of the Chimney Tops 2 fire on the Great Smoky Mountains National Park water and soil. She collects and then runs soil and water samples for a variety of parameters and is working with other departments at UTK to look at a wider impact of the fire including impact on plants, microbes, fungi, and other areas. She is working on statistical analysis of the collected data. Salley's research interests include water and soil quality, natural systems management, and restoration.

Alex Moore has been awarded the Appalachian Leadership Institute Fellowship from the Appalachian Regional Commission (ARC). From Bybee, Tennessee, Alex graduated this spring from the University of Tennessee with a bachelor's degree in political science; he is now a graduate student in the Master of Public Policy and Administration program at UT. Having previously interned with the cities of Morristown and Greeneville, Tennessee, he will now assist UT and ARC in hosting seven leadership sessions throughout ARC's 13-state region. These sessions will train professionals on how to improve local communities and bring jobs to the Appalachian region. After finishing his work with ARC and graduating with his Master's degree, Alex plans to work in local government in East Tennessee in either city planning or city administration.

Undergraduate Students

Matthew Montgomery is an undergraduate student in Civil Engineering. He has worked with Dr. Papanicolaou's team in the Hydraulics and Sedimentation Laboratory helping to perform an acid soil digestion procedure for watershed management. His primary interests lie in wetland mitigation and stormwater management. Matthew promotes environmental activism as the volunteer coordinator for the University of Tennessee Chapter of the American Society of Civil Engineers.

Caroline Stephens is an undergraduate student in Civil Engineering, set to graduate in May 2020. She is concentrating on water resources and environmental engineering. In the Hydraulic and Sedimentation Laboratory she has assisted on multiple projects: observing open channel flows effect on certain structures and tagging soil with rare earth elements in order to trace erosion. Additionally, she assisted in surveying stormwater management practices in Farragut, Tennessee. She enjoys learning about stormwater and how it is managed in different areas.

Andrew Tsay is a third-year undergraduate student from Memphis, Tennessee, majoring in Civil Engineering with a concentration in construction engineering and water resources engineering. Since Spring 2019, Andrew has been helping Dr. Thanos Papanicolaou with sediment transport concerning virtual velocity tests by observing particle behavior in different flow conditions and shear stresses. With those tests, he helped with video and image processing using MATLAB programming. Andrew is now working to organize data about culverts, manholes, and basins from the Town of Farragut.

ISSE Advisors & Students

Khalid Alshibli
- Zaher Jarrar, (G) CEE

Bruce Barry
- David Grant, (G) Microbiology
- Jyotirmoy Mondal, (G) Biochem.

Abhijeet Borole
- Erin Essington, (U) Chem. Engr.

Kimberly Carter
- Alec Bissell, (U) CEE
- Rebekah Kish, (U) CEE
- Ryan Livesey, (U) CEE
- Sharon Smith, (U) CEE
- Leah Stephens, (U) CEE
- James Throckmorton, (U) CEE

Timothy Ezzell
- Emily Isaacs, (U) Public Policy
- Grace Medley, (U) Public Policy
- Alex Moore, (G) Public Policy

Terry Hazen
- Maria F. Campa, Post-Doc Researcher
- Andrew Putt, (G) Geology
- Sa'ad Abd Ar Rafie, (G) CEE
- Zabrenna Griffiths, (G) Genome Sci.
- Scott Satinover, (G) Energy Sci.

Mingzhou Jin
- Wenquan Dong, (G) ISSE
- Rongyun Tang, (G) ISSE
- Rui Zhou, (G) ISE

Thanos Papanicolaou
- Hilafu T Hilafu, (G) CEE
- Matthew Montogmery, (U) CEE
- Nicholas Pettit, (U) CEE
- Caroline Stephens, (U) CEE
- Andrew Tsay, (U) CEE

Sean Schaeffer
- Aubrey Fine, (G) Plant, Soil & Env. Sci.

John Schwartz
- Taylor Blackstone, (G) CEE
- Jason Brown, (G) Biosystems Engr.
- Jeremy Melton, (G) CEE
- Salley Reamer, (G) CEE
- Andrew Veeneman, (G) CEE
- Guy Zimmerman, (G) CEE
- Robert Groves, (U) CEE
- Caroline Jones, (U) Chem Engr.
- Kelly Leffler, (U) CEE
- Nicholas Pettit, (U) CEE

Sheila Webster
- Gregory Corson, (U) ME

Jie Wu
- Jiamei Huang, (G) EECS
- Songyi Liu, (G) EECS
- Rania Oueslati, (G) EECS
- Jiyu Meng, (U) EECS

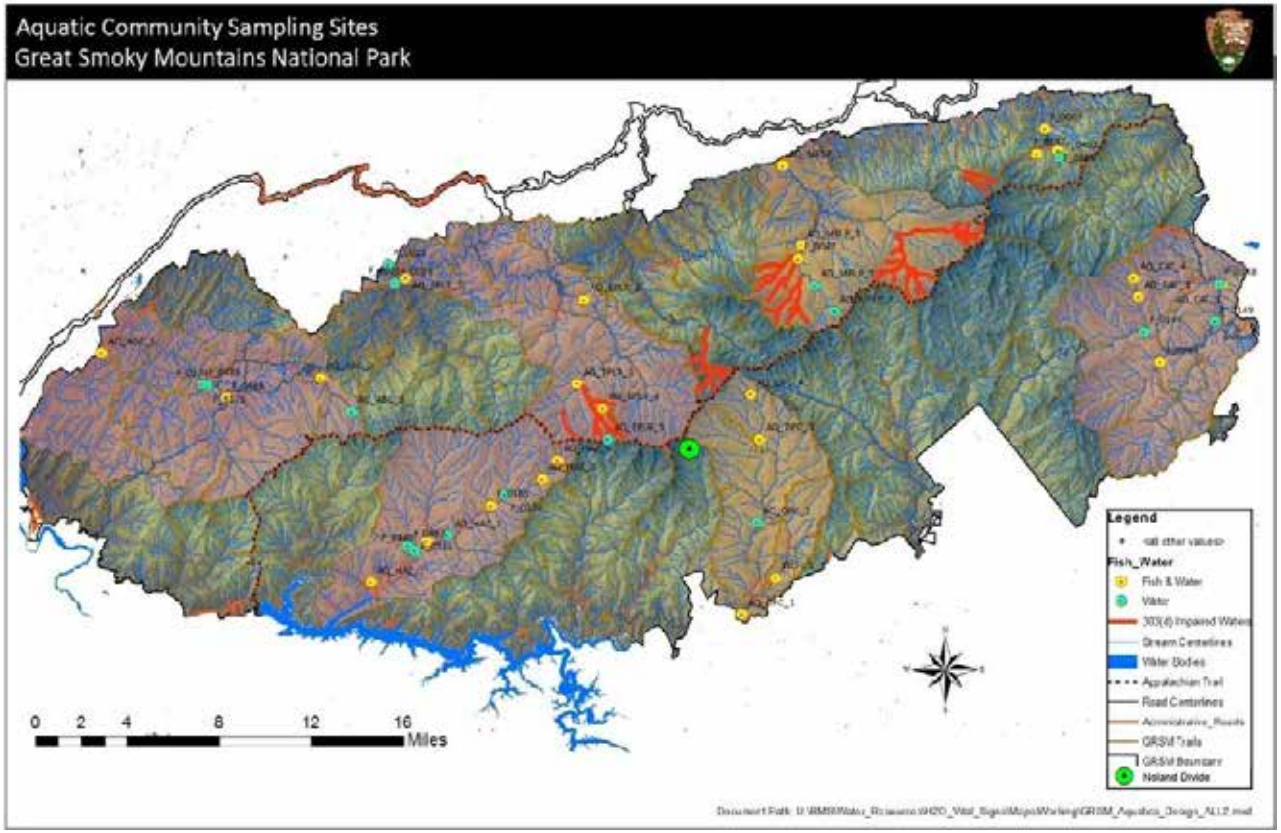
Research

TENNESSEE WATER RESOURCES RESEARCH CENTER (TNWRRC)

Improving GRSM's Understanding of Its Natural Resources and Processes to Enhance Protection of the Park's Resources

PI: John S. Schwartz, Department of Civil & Environmental Engineering, University of Tennessee, Knoxville

The Great Smoky Mountains National Park (GRSM) Annual Water Quality (WQ) Monitoring Program consists of detailed hydrologic and WQ monitoring at Noland Divide Watershed (a high-elevation forested site) and park-wide Vital Signs Program stream survey monitoring. To effectively develop a monitoring program of vital signs, the National Park Service Inventory and Monitoring Networks prioritize research questions and monitoring data needs related to focal resources important to each park; agents of change or stressors that are known or suspected to cause changes in those focal resources over time; and key properties and processes of ecosystem health (e.g., weather, land use patterns, water quality, and soil nutrients). A special study in progress characterizes throughfall deposition, rainwater that filters through the forest canopy. A new MS student, Jason Brown, recently started with the project. His proposed research will be to better understand the dynamics of dissolved organic carbon in the stream water and its influence on acidification.



Map of Park with collection sites, Noland Divide watershed (NDW) site, 303(d) listed streams (noted in orange), and vital signs watersheds shaded in pink/lavender.

TNWRRC FY 2018 USGeological Survey Research Projects

Project Number: 2017TN129B Evaluation of fecal indicators and pathogens at recreational beaches in central Tennessee

PI: Frank C. Bailey, Department of Biology, Middle Tennessee State University

Primary Findings: Two Tennessee freshwater beaches (Cedar Creek [CC] and Barton Springs [BS] Recreational areas) were sampled eight times during Summer 2018. Ten sand and three water samples were collected and analyzed for Escherichia coli and methicillin resistant Staphylococcus aureus (MRSA). MRSA was found in 98% of sand and 94% of water samples. E. coli was found in 100% of both sand and water samples. Interactions were found between sites and date for sand concentrations of both E. coli (ANOVA, $F_{7,144} = 4.93$, $p < 0.001$) and MRSA ($F_{8,149} = 4.96$, $p < 0.001$). MRSA was highest at both sites during August with levels >104 CFU/100g

sand, while E. coli was highest in August at CC and June/July at BS with levels ~104 MPN/100g sand. The average for both MRSA and E. coli was > 100 CFU(MPN)/100g sand for all dates. For water, both E. coli ($F_{7,32} = 12.5$, $p < 0.001$) and MRSA ($F_{7,28} = 9.45$, $p < 0.001$) showed interactions between sites and date. MRSA was highest at CC in September and in May at BS, both having >100 CFU(MPN)/100mL. The highest E. coli concentration was at CC in July and June at BS, both having ~100 CFU(MPN)/100mL. In contrast to sand samples, water concentrations of MRSA and E. coli were typically <30 CFU(MPN)/100mL at both sites. The presence of fecal bacteria and pathogens at these beaches demonstrates potential risk to beachgoers, especially those who dig in the sand at the shoreline and do not wash their hands before eating.

Project Number: 2017TN130B Sediment Source Tracking in Urban Watersheds: An Application in the Second Creek Observatory

PI: Jon Hathaway; Co-PIs: Thanos Papanicolaou and Chris Wilson, Department of Civil & Environmental Engineering, University of Tennessee, Knoxville

Primary Findings: This project looks at sediment transport in urban streams, aiming to reduce sediment pollution and ameliorate the impacts of urbanization on local streams. We use the Second Creek Observatory (SCO) in Knoxville as a case study of urban stream processes. We want to identify sediment sources and decipher transport dynamics during stormwater runoff events. Initial sediment sampling at the site indicate that material from impermeable surfaces were too coarse for using isotopic fingerprinting methods. We use existing flow and sediment concentration data from the SCO to develop hysteresis loops proved promising. Data from ten storm events over a one-year period were analyzed, yielding six clockwise loops and four anti-clockwise loops. The clockwise loops suggest source material exhaustion from the limited availability of the material in the impermeable surfaces nearest the stream channel. The anti-clockwise loops suggest possible stream bank erosion from the sediment-starved waters, delivered during subsequent events following a flush of the readily available material.

Project Number: 2017TN131B Characteristics of Fine Sediment Embeddedness: Towards Understanding Drainage Network Transport Lags

PI: John S. Schwartz, Department of Civil & Environmental Engineering, University of Tennessee, Knoxville

Primary Findings: Understanding the biophysical dynamics of fine sediment infusion into streambed gravel is critical to improving management and restoration strategies for impaired streams. However, there is no standard technique to field measure and assess its impact on benthic habitat quality. In general, embeddedness is defined as the extent to which streambed gravel and cobble are surrounded or covered by fine sediment and visually categorized by estimates of the percentage surface area covered by fines or the quantity. Differences in definitions have led to inconsistencies for how it is measured. Grab samples from 12 streams were completed in three categories: urban impaired, urban restored, and ecoregion reference. Percent fines (<2mm) and percent organic matter were significantly greater in urban versus ecoregion references streams. Various ratios of particle size percentages were investigated but due to variance none were found to be an ideal quantitative measure of embeddedness.

Project Number: 2017TN132B Examining Sediment Rating Curve Hysteresis with State-of-the-Art Sensors

PI: Thanos Papanicolaou; Co-PIs: Achilles Tsakiris and Jon Hathaway, Department of Civil & Environmental Engineering, University of Tennessee, Knoxville

Primary Findings: Sediment rating curves are central to successful sediment management. One difficulty in developing these curves is the time lag, or hysteresis, that exists between water and sediment fluxes, which can introduce significant variability in sediment flux estimations. Our ultimate goal is to incorporate artificial particles tagged with miniature Radio Frequency IDentification (RFID) sensors to determine how long it takes a particle to move through a stream, considering both its travel and resting times. We will combine the sediment flux information with flow discharge to resolve the relations between water and sediment for the rising and falling limbs of a hydrograph. An anti-collision feature was applied to our existing PAPTSAK RFID detection software to automatically interrogate multiple transponders in the vicinity of the antenna. The transponders were also equipped with inclinometers to improve detection capability by correcting for the weaker signals when the orientation of a transponder relative to the antenna changes. The likelihood of detecting transponders drops significantly when the particles are no longer perpendicular to the antenna. The tracking of these particles was

successfully conducted in a flume at the Hydraulics & Sedimentation Lab and are ready for field trials. The particles have other applications such as scour estimation around bridges or measuring flows through culverts.

Project Number: 2017TN133B
Field study of spatiotemporal variability in bedload transport in mountainous boulder arrayed streams for development of a mechanistic model

PIs: Thanos Papanicolaou; Student Investigator: Micah Wyssmann, Department of Civil & Environmental Engineering, University of Tennessee, Knoxville

Progress to Date: This student award to Micah Wyssmann, a Ph.D. candidate working with Prof. Papanicolaou, supports his research in the development of a mechanistic bedload transport model that can predict fluxes in mountain river reaches with ubiquitous boulders, while capturing important timescales of pulsation in bedload transport rates. Specifically, the support allowed Micah to attend *River Flow 2018*, the annual meeting of the International Association of Hydro-Environment Engineering and Research in Lyon, France. His presentation, "Lagrangian modeling of bedload movement via the impulse entrainment method" discussed a conceptual framework to provide a better understanding of the intermittent behavior of bedload transport. The framework is based on the impulse entrainment method and predicted impulse statistics of particle resting time, t_R, and the magnitude of hydrodynamic momentum transfer (or impulse) during entrainment, I_{ent} by simulating turbulent time series realizations with a generic, regime-based streamwise velocity spectrum. Model predictions showed that an increase in stress was correlated with a sharp decrease in the average t_R and an increase in I_{ent}. The resulting manuscript was published in the *Journal of Geophysical Research: Earth Surface*.

Project Number: 2018TN134B
Rethinking bank stabilization in Tennessee to develop a classification protocol for agricultural and urbanized systems.

PIs: Thanos Papanicolaou; Co-PIs: John S. Schwartz and Christopher Wilson, Department of Civil & Environmental Engineering, University of Tennessee, Knoxville

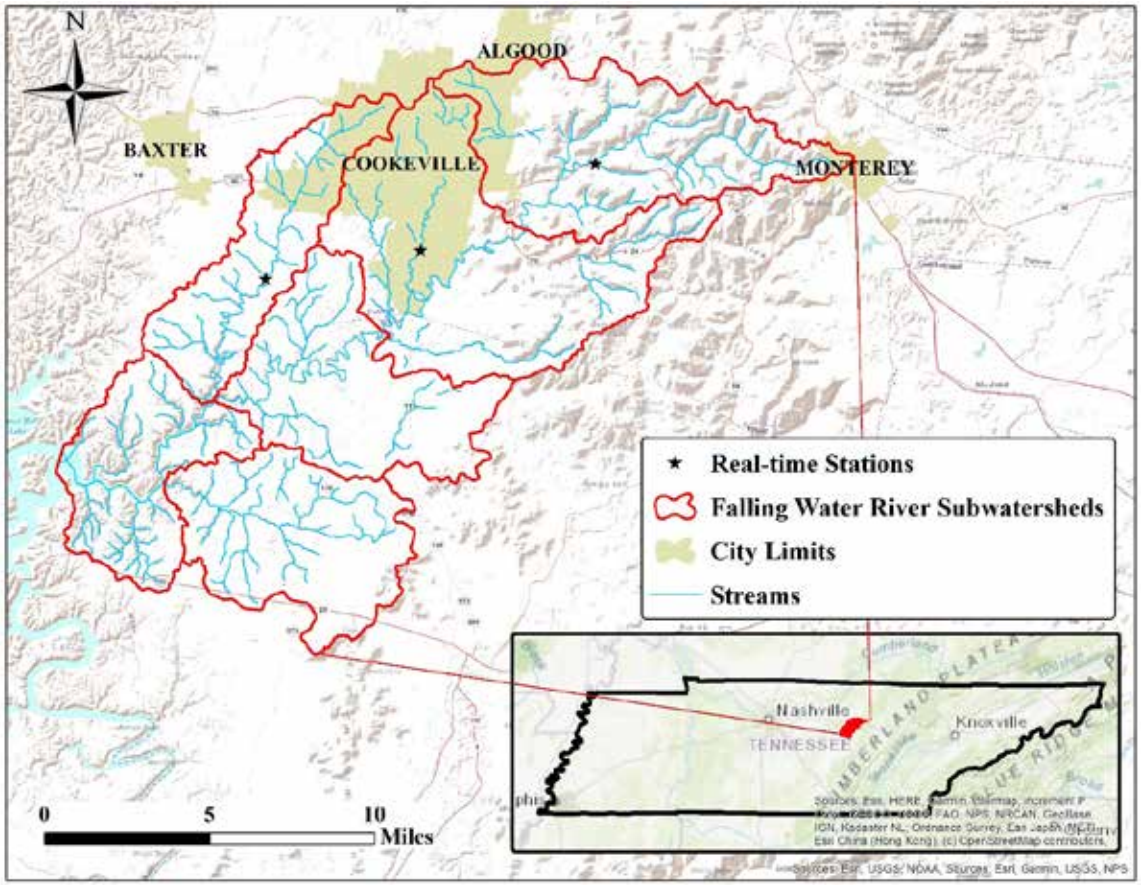
Progress to Date: There is a critical need in the state to develop a decision making tool for selecting the most appropriate bank stabilization method according to site characteristics. We are taking the first steps to develop such a tool by conducting detailed measurement of flow and stream bank interactions in Tennessee's Beaver Creek and its tributaries. All streams where we have erosion pins have active USGS gauging stations for flow data. These pins are being monitored on a regular basis. The flow measurements include large scale particle velocimetry and traditional wading rod measurements. The detailed measurements are designed to represent the distribution of the near-bank shear stress when secondary currents are present during higher flows as well as estimate the critical erosional strength and other sediment erodibility parameters for measuring bank erosion. The combination of the bank erosion rates and flow measurements are useful for river modeling as most models assume uniform flow conditions and consider a near-bank shear stress distribution derived from laboratory experiment. The presence of the secondary currents increases the magnitude of the depth-averaged side-wall shear stress by at least a factor of 2.0.

Project Number: 2018TN135B
Low-cost real-time streamflow network for Falling Water River Watershed

PI: Alfred J. Kalyanapu, Department of Civil & Environmental Engineering, Tennessee Tech University

Task 1 – Assemble a low-cost real-time enabled water level sensor

Progress to Date: The project team built a low-cost, real-time water level sensor that includes a Particle Electron 3G Micro-controller (Particle, 2019), 1800 mAh Li-Po battery, Maxbotix MB 7920 Ultrasonic Sensor, 3.5V solar panel, half proto-board, few wires for connections and an IP-67 waterproof enclosure. Each sensor node is configured to collect the water level every 15 minutes and the nodes publish the data on a Cloud-Hosted Realtime Data Services (CHORDS) Server at Tennessee Tech. CHORDS is a real-time data service infrastructure developed by NCAR and their collaborators that provides easy-to-use system to acquire, navigate, and distribute real-time data streams via cloud services and the internet. It is supported by the National Science Foundation EarthCube initiative, which is a community-led cyberinfrastructure initiative for the geosciences Daniels et al., (2016). TTU established the CHORDS server using our IT infrastructure.



left: Falling Water River Map and Location of Current Real-time Stations

Project Number: 2018TN136B
Three-Dimensional Modeling of River Flows Under Extreme Weather Scenarios

PI: Dr. Jejal Reddy Bathi, Department of Civil & Chemical Engineering; Co-PI: Kidambi Sreenivas, Department of Mechanical Engineering & Sim Center, University of Tennessee at Chattanooga

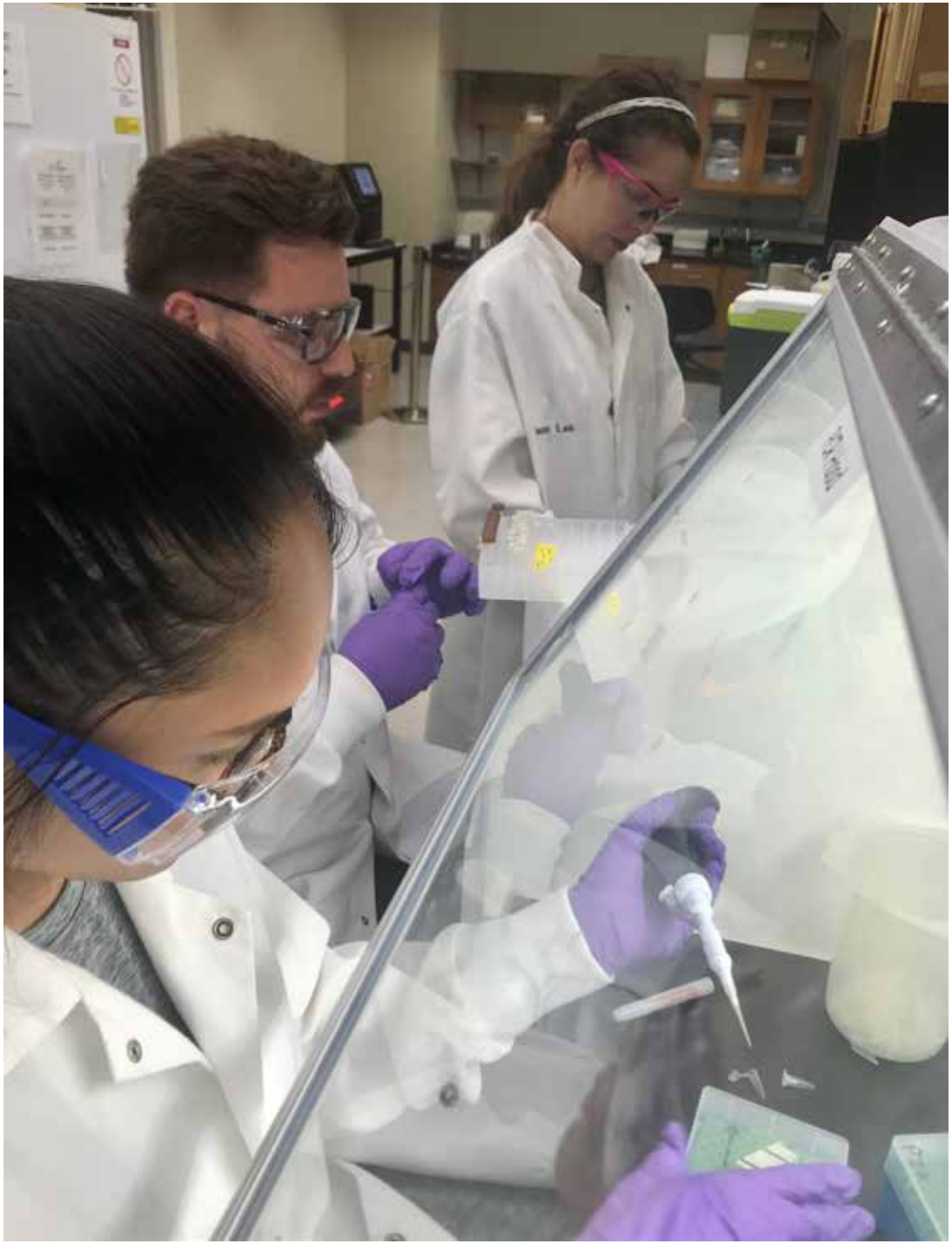
Progress to Date: This research uses a 3D hydrodynamic and water quality simulation model for river management under extreme flow conditions. U.S. EPA approved Environmental Fluid Dynamics Code (EFDC) 3D is being developed for the Tennessee River in the urban stretch of Chattanooga. Despite its wide applicability, its complex grid generation process makes the use of the EFDC model difficult for end-users. It uses a FORTRAN based GEFDC program, which requires a substantial amount of knowledge and craftsmanship to generate a compatible grid. In order to make the grid generation process automated and compatible, a MATLAB based structured grid generator is being developed as part of our current research.

Task 2 – Field-testing of the sensors

Progress to Date: During this task, the project team tested the outdoor performance of the sensors on TTU's campus. The team monitored the logger's readings including the distance measured by the ultrasonic sensor and the Li-Po battery voltage. These tests were done over a course of two weeks, and once it was established that the sensors were working well, they were installed along the Falling Water River Watershed.

Task 3 – Installation of sensors and network

Progress to Date: The project team identified locations along the Falling Water River and its tributaries to install the sensors. Selected sites had good cellular coverage, relatively open areas with good solar coverage throughout most of the day, and the presence of bridges where we could attach a sensor box. The selected locations are: i) along Pigeon Roost Creek at the Cookeville Wastewater Treatment Plant, ii) along Falling Water River near Adams Acres Bridge, and iii) along Cane Creek near Ditty Road.



Methane Center

NSF award: Impacts of Biocides Associated with Hydraulic Fracturing on Aquatic Microbial Communities

PIs: Terry Hazen and Maria Campa, University of Tennessee, Knoxville

The Methane Center received an NSF award to study the environmental implications of biocides used in hydraulic fracturing, particularly antimicrobial resistance. This award is shared with Juniata College and Michigan Technological University. We collected water and sediment samples from 21 streams in Pennsylvania and completed the first summer field sampling. These samples have now been processed for cell counts, ions, organic acids, and trace metals and will be processed for biocides, and microbial community composition and function as well as for cultivation of biocide resistant strains. Students from Juniata College, an undergrad only institution, and an undergrad student from the University of Guam came to UT where Drs. Campa and Hazen trained them on microscopy, IP-OES, and molecular biology.

A concern with a methane based economy is its dependence on water to fracture shales to release natural gas. This water flows back to the surface carrying salts, organics, and other dissolved solids. The Methane Center is collecting preliminary data to determine whether methane hydrates can be applied to efficiently desalinate and reuse this water. Methane hydrates consist of natural gas trapped on a frozen water matrix (bubble). Methane hydrates naturally occur on the sea floor. Dr. Claudia Rawn has already developed a method to create methane hydrate in her lab, and Dr. Campa is working with her and Dr. Hazen to modify her methodology so it can create methane hydrate using high salt media. Once that is achieved, we will add organics and other hydraulic fracturing flowback components to measure hydrate formation efficiency and desalination efficiency.

left: Visiting undergraduates from Juniata College and University of Guam learning various molecular biology techniques such as PCR and DNA electrophoresis, and preparing ICPOES standards.

JRCEEC & FEWSTERN

US-China Food-Energy-Water Systems Transdisciplinary Environmental Research Network (FEWSTERN). NSF Award Number: CBET 1739474

PIs: Frank Löffler, Jie Zhuang, Gary Sayler, Timothy Rials, Virginia Dale

The FEWSTERN team has made tremendous headway bringing U.S. and Chinese researchers, policy makers, and stakeholders together to discuss national and global environmental solutions that enable sustainable exploitation of natural resources under conditions of environmental change, population growth, and urbanization. The project has organized two annual symposiums and three topic workshops on the nexus of food, energy, and water systems (FEWS) in China and the US with ~600 participants from more than 50 universities, government agencies, and companies.

Project activities have led to a US-China crosscutting research coordination network that functions to identify transdisciplinary environmental grand challenge research opportunities and hurdles at the FEWS nexus; overcome bottlenecks to interdisciplinary research among collaborating U.S. and Chinese institutions and researchers; and establish model platforms for education, training, communication, and efficacy evaluations of the outputs of international, cooperative activities. This project has already seen success in changing the views of scientists from disciplines other than environmental science through a series of activities.

Appalachian Tourism

Trends and Strategies for Tourism in Appalachia

PIs: Timothy Ezzell and Catherine Wilt, ISSE; Rachel Chen and Stefanie Benjamin, Department of Retail, Hospitality and Tourism Management; Bruce Decker, Collective Impact, LLC, Huntingdon, West Virginia

Since 2017, the research team has been studying Appalachian Tourism, a $60 billion industry, for the Appalachian Regional Commission. In the past year, the team concluded the preliminary research tasks, which included surveys and economic impact assessments, and conducted site visits to communities and destinations across the thirteen state Appalachian Region: Erwin, Tennessee; The Mothman Festival in Point Pleasant, West Virginia; Straub Brewery in St. Mary's, Pennsylvania; Berea, Kentucky; Tiffin Motor Homes, Red Bay, Alabama; Jamestown, New York; Cherry Springs State Park, Coudersport, Pennsylvania; and Boone, North Carolina.

Preliminary findings from the research have uncovered considerable information about the state of Appalachian tourism.

- Outdoor recreation is the basis for Appalachian tourism, and public lands are the foundation of outdoor recreation. Thus, conservation of public lands is critical to the Region's tourism industry.

- While Appalachia contains 420 counties, most tourism is concentrated in a handful of jurisdictions. Ten counties comprise about a third of

tourism revenues. Thirty-four counties employ half of the region's tourism workforce.

- While the majority of counties have modest levels of tourism, the industry is still vital in these areas. Tourism helps communities attract and sustain important services and amenities such as lodging and dining establishments. These, in turn, help grow other industries and improve the quality of life for local residents.

- Diversity is a challenge for many areas. While minority tourism is one of the fastest growing segments of the tourism industry, African-Americans comprise just one percent of visitors to the region. Minorities are also underrepresented in the tourism industry, especially in leadership positions. As the traveling public becomes more diverse, Appalachian communities must learn to become welcoming places for all visitors.

- Social media and the shared economy are radically changing the tourism industry. Services like Uber, Airbnb, and Yelp are transforming the way people travel and share their experiences. Communities must adapt their strategies and improve their digital infrastructure to meet these new demands.

- Communities must carefully weigh the environmental costs of tourism. ATV trails, for example, are brining much needed revenue to communities reeling from the coal transition. At the same time, these trails can have significant environmental impacts. The research community should work with these areas to help mitigate these impacts while promoting sustainable growth.

- Tourism is difficult to measure. The distinctions between tourism and other forms of travel are often blurred. Yet, while these metrics are hard to discern, there are emerging standards for measuring travel impacts. States and communities should adopt common standards for measuring and sharing travel statistics.

These findings and others are being compiled into a final report that will be completed in early 2020.

left: The Mothman Festival celebrates a local folk legend. The one-day event brings over 12,000 visitors to Point Pleasant, a small WV community on the Ohio River.

ISSE Seed Grant Projects

ISSE makes annual funding available for multidisciplinary, multi-investigator research and support. Each year, ISSE awards about four seed grants to support research projects related to sustainability, especially projects related to water, energy, and food sustainability that have potential for external funding opportunities. The aim of the seed grants is to support project teams as they develop the capability to secure external funding. ISSE expects the funded teams to submit at least one external grant proposal and one article to a peer-reviewed publication with necessary acknowledgement to ISSE.

2019-20 Projects

Nanomaterial-strengthened biomimetic heavy metal sensing and absorption for drinking water treatment.

Anming Hu, PI; Jayne Wu, Co-PI

The primary objective of this project is to seek proof-of-concept for nanomaterial-strengthened biomimetic sensing and absorption of heavy metals for drinking water treatment. Interdigitated electrodes printed with nickel nanoparticle ink and then coated with Au can possess high conductivity, high stability and high surface area, all crucial to improve electrical-based sensing. The interactions with biomimetic probes and AC voltages provide us a tool kit for versatile and facile heavy metal ion detection. Further, surface absorption of heavy metal ions can be realized through a carbon-fiber reinforced TiO_2 nanowire membrane. The data generated from this project will be used as the preliminary data for at least two external grant applications.

Analyzing Strategies for Diverting and Managing Organic Waste Streams in Tennessee.

Christopher Clark, PI; Co-PIs: Burton English, Chad Hellwinckel, Edward Yu, Shawn Hawkins, Forbes Walker, Qiang He, Becky Jacobs, Charles Sims

Metropolitan areas are seeking to extract organic materials from municipal waste streams and redirect these wastes into the production of stabilized products with beneficial end uses. However, extraction difficulties and high costs have hindered these efforts. For example, single stream separation often yields inferior, contaminated compost. Cost overruns of large centralized facilities often make composting a contentious issue. Further, transportation from populated areas to large, isolated composting facilities carries a high carbon footprint. Small-scale neighborhood composting in urban gardens has also been problematic, probably because compost products are not a direct income stream of the urban gardens and its workers. Thus, there is a need to evaluate alternative technologies for diverting and managing organic wastes.

We propose to conduct a preliminary feasibility and economic and environmental analysis of two basic scenarios: (i) the status quo, landfilling organic waste, accounting for collection, and utilization of landfill gas as a renewable energy source; and (ii) diverting and recycling the organic waste for its nutrient value. There are a number of alternative technologies for accomplishing (ii), including: dry anaerobic digestion; wet anaerobic digestion; static pile composting; turned windrow thermophilic aerobic composting, and in-vessel forced air aerobic composting. We will analyze the strengths and weaknesses of each of these technologies.

Multi-Sensor Data-Driven Inspection/ Maintenance of Green Infrastructure.

Anahita Khojandi, PI; Jon Hathaway, Co-PI

The objective of this study is to use physical data streams from low cost sensors placed in bioretention areas to identify trends that suggest poor performance. The resulting algorithms can be used later in a real time dashboard to alert municipal staff when inspections should be performed. The project will include two main tasks: laboratory experiments; and developing predictive models.

Task 1: A column study will be developed that will allow us to force poor performance on lab scale bioretention areas by introducing conditions that can lead to various maintenance requirements. This is critical, as within the timeline of this project it is improbable than any bioretention being monitored in the field (a potential alternative approach) would move from performing well to being in critical need of maintenance (for example, complete clogging of upper soil layers). The columns will be equipped with nodes consisting of low cost microcontrollers and sensors. The sensors will include (at a minimum) soil moisture, water level, and a leaf sensor (plant water stress). Additional sensors may be added to the node as needed. Sensors will take high-frequency measurements, and the data will be streamed from the microprocessor to a cloud server using a cellular module.

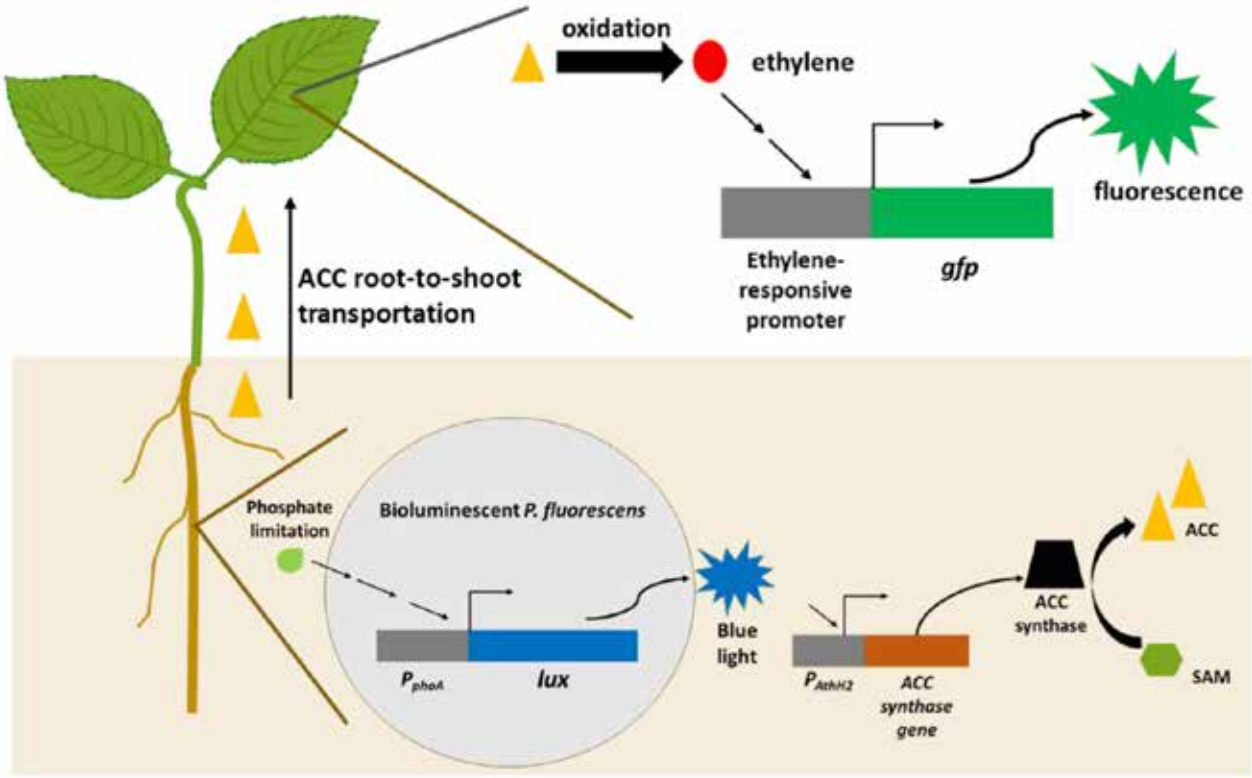
Task 2: We will analyze the data for patterns that can indicate the need for maintenance in bioretention. Soil moisture is anticipated to be a valuable measurement in bioretention as it is applicable to drainage patterns, drainage rates, and plant access to water. Other measurements may include parameters such as water depth to ensure the system is appropriately draining into in situ soils or through underdrains, etc. Such objective measurements would allow identification of systems that need maintenance as opposed to relying on a qualitative, primarily visual assessment.

Emerging synthetic biology for plant phytosensing and agricultural sustainability.

Steven Ripp, PI; Co-PIs: Tingting Xu, Sarah Werner, Scott Lenaghan

The objective of this research effort is to develop a proof-of-concept multi-organism signaling cascade capable of sensing and relaying an underground soil signal (i.e., phosphate bioavailability) to an easy-to-detect optical signal in plant leaves (i.e., fluorescence). The proposed signaling cascade will consist of the rhizosphere-colonizing bacterium Pseudomonas fluorescens as a chemical sensor for phosphate levels in soil and the model plant Arabidopsis thaliana to display an endpoint fluorescence signal for detection. The signaling relay will be achieved by three genetic switches along with the root-to-shoot transport of 1-aminocyclopropane-1-carboxylate (ACC; the immediate precursor for the phytohormone ethylene) through the plant xylem.

Once delivered to the shoot, ACC is oxidized and converted to ethylene, which serves as the signaling molecule to activate the third (and last) genetic switch of the cascade, a fluorescent protein reporter gene (gfp) regulated by a GCC box-containing ethylene-responsive promoter. To this end, a chemical signal below ground in the soil (i.e., reduced phosphate bioavailability) is sensed by the rhizosphere microbe, captured by the plant root, transferred to the leaf canopy using the plant's vascular system, and ultimately displayed in the form of an optical signal available for above-ground detection.



right: Schematic illustration of the proposed signaling cascade.

2018-19 Projects

Gas Driven Fracture During Gas Production using 3D Synchrotron Computed Tomography (SMT)

PIs: Khalid Alshibli and Claudia J. Rawn

The objective of this study is to identify the evolution of gas flow paths and patterns that are associated with underlying coupled processes of fines migration, clogging, over-pressurization, and gas-driven fracture, through unique in situ experiments that involve monitoring gas invasion of porous media with fines. 3D direct visualizations of fines clogging, and gas driven fracture are will

be monitored by means of 3D Synchrotron Micro-computed Tomography (SMT) imaging. Successful completion of the project will provide fundamental understanding of underlying coupled processes of fines migration, clogging, over-pressurization, gas-driven fracturing to evaluate optimal conditions for the various production strategies (most notably, depressurization and CH_4-CO_2 exchange). This in turn allows us to select the most efficient production technology adequate for the local geological/geographic conditions (e.g., water depth or permafrost depth, pressure-temperature condition, sediment type, reservoir thickness, hydrate concentration).

Investigate Gas Production from Organic Matter in Sediments to Estimate Methane Release from Water Holding Structures

PI: Abhijeet P. Borole; Co-PI: Thanos Papanicolaou

Human beings have interrupted water flow in nature for ages to extract water for irrigation or energy from hydroelectric dams. These water bodies accumulate natural organic matter that degrades in the water column, producing carbon dioxide. Anaerobic sediments produce methane, a potent greenhouse gas. Large amounts of organic matter accumulate behind dams as well as in calm river waters, on the order of 200-530 x 106 tons C/year, releasing significant amounts of CO_2 & CH_4. Removal of the sediment is necessary for long term operation of the water systems. We propose to investigate methane release from dam sediments and natural plant biopolymers to improve estimation of this contribution to the carbon cycle. Additionally, we propose to get preliminary data on valorization of the sediment organics via H_2 production. This approach can lead to reduced GHG emissions, improved economics of sediment removal, production of clean H_2 for transportation and as an energy source, and minimize anthropogenic effects on global climate change. The project has two tasks: (1) assess carbon dioxide and methane release from soluble and particulate organic matter in water; and (2) produce methane and hydrogen from sediment organic matter and individual biopolymers.

Other ISSE Projects (External Funding)

Research & Policy Study - Adoption of Alternative Fuel Vehicles

Funded by DOE, UT-Battelle & Oak Ridge National Laboratory

PIs: Mingzhou Jin and Naiwei Lu

This study explored the national hydrogen refueling infrastructure requirement along major US interstate highway corridors to support the deployment of fuel cell electric trucks (FCETs) for the national long-haul trucking fleet. Given the long-haul trucking shipment demand in 2025 projected by the Freight Analysis Framework, locations and capacity of hydrogen stations were identified for inter-zone freight flows, and the total daily refueling demand was estimated for intra-zone flows for each FAF zone.

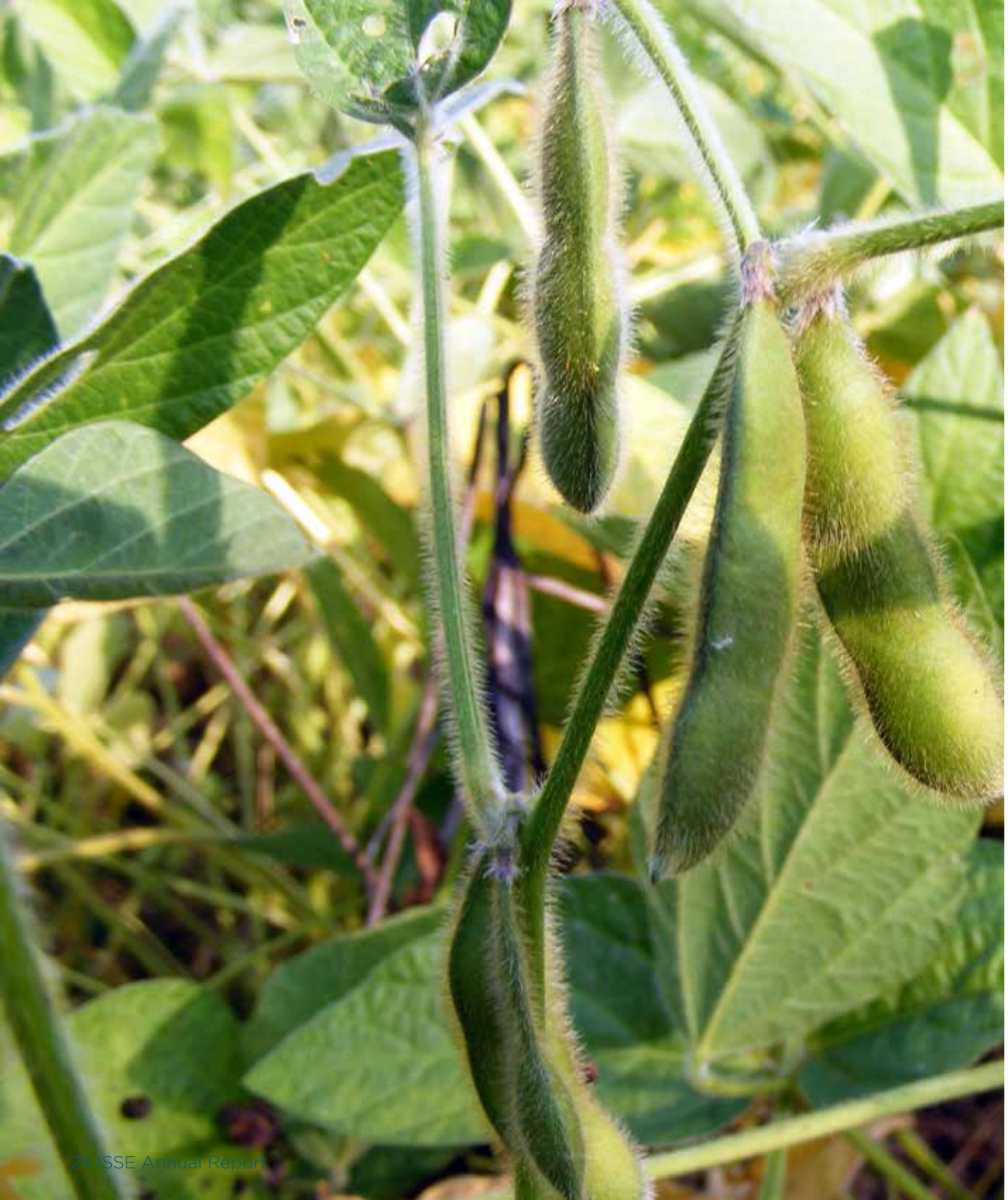
Based on the infrastructure deployment results, we conducted an economic feasibility analysis of FCETs by evaluating the total ownership cost. We found that when the FCET penetration is relatively high (e.g., 10% penetration), FCETs are competitive relative to the diesel technology in terms of fuel cost and idling cost, and could be economic viable if the incremental vehicle cost is reduced to meet the near-term FCET technology cost targets. We also observed that the station cost depends on regional factors, such as station capacity, which is a function of regional demand. Thus, one possible strategy for station roll-out is to have early investment in target regions where station costs are expected to be relatively low.

Coupled FEWS Modeling for Sustainability in the Global Crop Supply Chain

Funded by National Science Foundation Innovations in Food, Energy, and Water Systems (INFEWS)

PIs: Mingzhou Jin, Andrew Muhammad, Yaoping Wang

Keeping supply and demand in balance within global food systems requires identifying gaps in the global crop supply chain (SC), which includes production, storage, transportation, distribution, and consumption of crop. Because the global crop supply depends on variables such as changes in the climate, economy, government, society, and technology, solving problems within the SC requires advanced solutions such as computer modeling to account for problems like the growing inequities in water distribution and seasonal disparities worsening in the face of rapid climate change. Dr. Jin, Professor and Associate Department Head of Industrial Engineering and Director of ISSE, aims to help future-proof some looming problems in the SC with his research collaboration with Blasingame Chair of Excellence Professor Andrew Muhammad in



UT Institute of Agriculture. The duo has received a four-year grant from the NSF's Innovations in Food, Energy, and Water Systems (INFEWS) program for their proposal, "Coupled Modeling for Sustainability of the Global Crop Supply Chain with a Focus on China – US Interactions."

This research aims to advance modeling methodologies and improve understanding of the interactions of the global crop SCs within a framework that takes into account the variety of socio-political and environmental forces that can impact it. Having access to better modeling with more resolution to see impact at the local level should help farmers make decisions and engage in collective efforts to achieve fairer and more sustainable global crop systems. Additionally, research will attempt to identify technical, societal, and policy solutions to improve the sustainability and resilience of the global crop SC by looking at international trade between the US and China in wheat and soybean crops. Their large trade volume has a critical impact on the global sustainability of food, energy, and water, and the lessons learned from this particular US-China SC can be applied to other global crop SCs.

Soybean production is in important part of the global supply chain.

Data Analytics Support for Integrated Earth Model

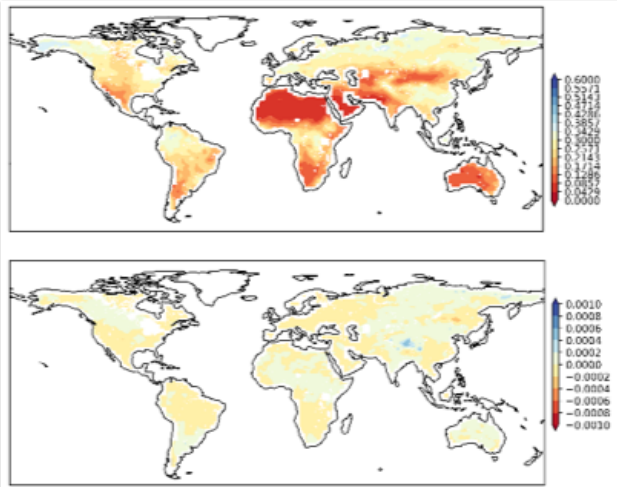
Funded by DOE, UT-Battelle & Oak Ridge National Laboratory

PIs: Yaoping Wang, Mingzhou Jin, University of Tennessee, Knoxville; Jiafu Mao, Oak Ridge National Laboratory

Background: Soil moisture is a key control of land-atmosphere flux exchanges, and accurate characterization of soil moisture can benefit many applications, such as weather forecast, drought monitoring, and Earth system modeling. The existing sources of soil moisture data (*in situ* measurements), satellite products, and model simulations each have some limitations in spatial coverage, vertical depth, and uncertainty. Developing high-quality long-term soil moisture datasets is a continuing challenge, especially at the regional to global scale.

Goal: The project aims to develop two long-term 0.5-degree global soil moisture datasets: (1) based on merging *in situ* measurements, remote sensing products, and model simulations, and (2) based on upscaling *in situ* measurements with machine learning techniques and proxy data that have complete spatial coverage (e.g. local weather, soil properties, vegetation). The project further aims to use the developed datasets to investigate long-term changes in historical soil moisture, and to attribute the changes to natural and anthropogenic forcings using detection & attribution technique.

Progress to Date: The team is currently finalizing the first dataset. We have collected *in situ* measurements, a long-term satellite product, reanalysis products, offline land surface model simulations, and coupled earth system model simulations from multiple sources. Using subsets or all of these datasets, the team has tested several merging approaches, including mean, median, optimal weighting, and emergent constraint, and produced merged products for four soil depths (0-10cm, 10-30cm, 30-50cm, 50-100cm) and four time periods (1950-2016, 1950-2010, 1981-2016, 1981-2010). We are evaluating these merged products using previously set-aside *in situ* measurements and short-term satellite products that were not used in the merging. The team is also analyzing long-term trends in the merged products. We have conducted a preliminary case study by applying machine learning technique on the West Texas Mesonet, and presented the results at the *Gordon Research Conference on Catchment Science* in 2019.



The average soil moisture climatology (top) and trend (bottom) of the historical transient simulations.

Future Plans: The team will finalize the first dataset and submit a journal paper during the next several months. During the next academic year, the team will conduct detection & attribution analysis based on the merged product and the collected factorial experiments. The team will also implement the tested machine learning technique globally for producing the second dataset. The team will also submit proposals for potential future expansion of this project to funding agencies such as Department of Energy.

Microgrid Optimization

Funded by DOE, UT-Battelle & Oak Ridge National Laboratory

PI: James Ostrowski

Dr. James Ostrowski worked with the Power and Energy Systems Group at ORNL on the Connected Communities project. He and his student developed optimization algorithms for the project, including the ability to model, predict, and control three-phase imbalanced loads in a residential microgrid setting under multiple scenarios. They integrated algorithms into the CSEISMIC microgrid controller, demonstrating its effectiveness in a lab setting. They also updated the algorithms based on field testing results.

Training & Education

TNWRRC

TNWRRC coordinates two statewide training and certification programs for the Tennessee Department of Environment and Conservation (TDEC). The Tennessee Erosion Prevention and Sediment Control Training and Certification program (TNEPSC) comprises three basic courses:

- The Level I Fundamentals of Erosion Prevention and Sediment Control for Construction Sites is a one-day foundation-building course for individuals involved in all aspects of land disturbing activities. It was offered 14 times with 1,262 people attending.

- The Level II Design Principles for Erosion Prevention & Sediment Control for Construction Sites is an intensive two-day course for engineers and other design professionals focused on engineering technology needed to plan and design practices and controls for preventing erosion and managing sediment and other stormwater pollutants on construction sites. It was offered five times with 156 professionals attending.

- The Level I Recertification is a half-day course for those who have successfully completed the Level I course and need to renew their Level I certification. Recertification is required every three years. It was offered 16 times with 1,009 people attending.

The Tennessee Hydrologic Determination Training Program (TN-HDT) is the second training program coordinated by TNWRRC for TDEC. The TN-HDT program consists of a three-day course designed to provide participants with a basic understanding of the underlying scientific principles, the legal ramifications, and the practical investigative techniques surrounding the determination of wet weather conveyances versus streams and other surface water features. The course was offered three times for a total of 43 people attending. The state regulations that established the TN-HDT certification program require those that successfully complete the TN-HDT course attend a one-day Refresher course every three years to maintain their certification. The one-day refresher course was offered four times with 29 persons attending.

The Stormwater Control Measures Inspection and Maintenance Workshop is a two-day foundation-building course for individuals responsible for the inspection and maintenance of permanent stormwater management practices. The course is intended for design professionals, engineers and landscape architects; landscape and other green industry professionals; and inspection personnel from all levels of government. The SCM I&M course aims to build a solid working knowledge of proper operation and maintenance of permanent stormwater measures. Topics include the permanent stormwater management requirements in the MS4 general permit; the function, inspection and maintenance of key SCMs based on the new permanent stormwater manual; and annual inspection and reporting requirements by owners/operators of permanent SCMs. The SCMI&M course provides a Certification with 12 PDHs upon successful completion of a short certification exam. The SCM I&M certification is valid for three years. It was offered two times with 45 people attending.

ETCF Alt Fuels First Responders Safety Training

If you were responding to an accident and came across a vehicle powered with Liquefied Natural Gas (LNG), would you be able to intervene? There are currently almost 300 UPS trucks running on Tennessee roads that are powered by LNG. Alternative fuel vehicles (AFVs) are more common than ever on Tennessee's roads and highways, and it can be difficult to keep up with quickly changing technologies and safety procedures.

In partnership with the National Fire Protection Association (NFPA) and other dedicated sponsors, TNCleanFuels announced two First Responder Training Sessions for Alternative Fuel Vehicle Safety in Nasvhille and Knoxville in 2019. Thanks to our generous sponsors, we have been able to secure enough funding for these sessions to ensure that the costs remain affordable for First Responders in all situations and locales.

The NFPA's AFV Safety Training Program has reached more than 220,000 emergency responders to date. Their subject matter experts & instructors collectively offer more than 100 years of fire service experience, and have extensive instructional experience in the area of fire service tactics for AFVs. The program includes instructor-led classroom training as well as self-paced online training utilizing highly-interactive learning modules. The curriculum addresses electric, hybrid, and gaseous fuels such as CNG (Compressed Natural Gas), LNG (Liquefied Natural Gas), and propane autogas (also called LPG), and their flow and use in today's AFVs.

Worker Health and Safety Training at Department of Energy Facilities

ISSE made agreements with Roane State Community College to conduct pilot technical training courses in HAZWOPER ONLINE Refresher and Fundamentals of Industrial Hygiene. Training in both areas include hands on experience with devices and equipment used for on-site applications. ISSE observed and monitored courses, analyzing their relevance to the participants' job titles such as Safety Engineer, Safety Technician, First Responder, Hygienist, etc.

ISSE collected and analyzed data on student performance, course evaluations and participants' likelihood of using what they learned in their current jobs. ISSE sponsored Dominique Joyner, UT Microbial Ecology and Lab Manager, for the GreatEST training in Iowa to become a qualified trainer for future courses.

Other activities included assistance with planning and implementing of the yearly DOE Advisory Committee meeting in Amarillo, Texas and a guided tour of the Pantex Weapons Plant. NIEHS provided guidance on goals and priorities to promote increased awareness of HAZWOPER and Worker Health and Safety Training. The Research Director also participated in the Awardee Meeting and Trainers Exchange in Pittsburgh, focusing on "Exploring Workplace Training Interventions Addressing Workplace Stress and Addiction."

To implement their mission statement and fulfill a grant from the National Institute of Environmental Health and Sciences and administered by the Partnership for Environmental Technology Education (PETE), ISSE's Dr. Sheila Webster, Research Director, and Rex Short, Research Associate, worked to develop policies, technologies, and educational programs that cut across multiple disciplines. This included training for DOE workers at Oak Ridge Operations, Savannah River, and the Portsmouth sites .

HAZWOPER Refresher Training at Roane State Community College shows how to properly use personal protective equipment.

Appalachian Community Technical Assistance and Training Program (ACTAT)

According to the Appalachian Regional Commission, over 10 million people live in the rural areas of the Appalachia. Many of these communities have limited financial resources to provide and sustain drinking water and wastewater services for their citizens. As part of the ACTAT Program, ISSE researchers are working with West Virginia University's National Environmental Services Center and the University of Kentucky's Water Resources Research Institute to provide technical assistance for water services to these in rural Appalachian communities.

ACTAT provides free training sessions to community leaders and water utility service personnel that lead to one-on-one technical assistance and outreach activities. The team uses the joint USDA-EPA Workshop-in-a-Box to guide the utilities through a self-assessment of ten work related categories including product quality, financial viability, and operational optimization. The team works with the utilities to identify subject matter experts in engineering, extension, public health, natural resources, chemistry, biology, management, financial, social, and legal disciplines who can assist the utilities to improve their operations

Working with TDEC, ISSE researchers have targeted eight utilities to enlist for the first two Workshop-In-A-Box training sessions. The first training session was held on September 6, 2019 in Johnson City, TN.

Appalachian Teaching Project

The Appalachian Teaching Project (ATP) is a service learning program sponsored by the Appalachian Regional Commission for students from colleges and universities across the region. At the end of the semester, the students from all participating institutions gather in Washington to present their project to ARC's the staff and leadership. UT helped establish the ATP in 2001 and has participated every year since; Dr. Tim Ezzell has taught the UT class since 2002.

UT's 2018 ATP class, pictured above, partnered with Pickett CCC Memorial State Park, located near Jamestown, Tennessee. Students worked with park officials and local stakeholders to develop a plan to improve their dark skies programming and facilities. The students designed an improved dark skies observing field and created a a multi-day astronomical "star party" event to help promote economic activity while preserving the park's dark skies assets.

Outreach & Collaboration

TNWRRC

USEPA Memorandum of Agreement – Watershed Center of Excellence

A renewal memorandum of agreement (MOA) with USEPA for TNWRRC to be a Watershed Center of Excellence has been drafted. The prior MOA with the University of Tennessee, Knoxville included the Tennessee Department of Environment and Conservation (TDEC). The renewal will include UTK, TDEC, and the Tennessee Department of Agriculture (TDA). Currently, the draft MOA is under review by all parties.

Urban Waters Report Card

A major initiative implemented at TNWRRC this year has been the development of an Urban Waters Report Card. TDEC's Jennifer Dodd and Karina Bynum proposed the idea of MS4s communities having an assessment tool that can better demonstrate incremental improvements in water quality and ecological health of streams. MS4 staff will develop a grading system to provide user friendly information to multiple stakeholders on the conditions of their streams, which will provide for better justification of funding resources used to rehabilitate streams. Tennessee's major cities and surrounding counties are engaged in the report card development process, including Nashville Metro, Chattanooga, Memphis, Knoxville, Hamilton County, Shelby County, and Knox County. We have had numerous meeting with each jurisdiction and two state-wide meetings. At the state-wide meeting in July 2019, the group finalized a list of assessment categories in which metrics will be developed.

Tennessee Department of Agriculture

Director John Schwartz met with John McClurkin and Sam Marshall to introduce and obtain support for UT to assist in developing watershed plans that meet the USEPA requirements for the §319 program. The idea is that a UG/G level course will be offered at UT in which the focus of a class project will be the completion of a watershed plan acceptable for EPA approval. With an approved plan, UT researchers, watershed associations, and NRCS district offices can use the plan to obtain §319 funding. The first course will be offered the spring 2020 semester. Other issues were discussed with TDA regarding the need to have assessment and design tools for bank stability, nutrient monitoring across the state, and addressing some flooding issues.

Tennessee River Basin Network

The Tennessee River Basin Network (TRBN) initiated a request to TNWWRC for management support. It is currently partially funded by TVA. Ming Jin, Brad Collett, and John Schwartz meet with Shannon O'Quinn with TVA to discuss the potential opportunities and shared interests. Professor Collett of the UTIA Plant Science Department and the Landscape Architectural Program runs the Tennessee RiverLine Project, which is focused on the Tennessee River. TRBN focuses on natural resources whereas the RiverLine Project incorporates the communities next to the river.

The TNWRRC Advisory Board

The Director has met with several state agencies about the structure and make-up of an advisory board for TNWRRC. It was suggested rather than

the formal board structure that has been used in the past, a panel discussion format with more stakeholders may provide better information for TNWRRC to set priorities. About 20 stakeholders have been identified, and a panel discussion will be implemented next spring.

Stormwater Infrastructure Inventory and Mapping for the Town of Farragut Phase II

Thanos Papanicolaou, ISSE/Civil and Environmental Engineering; Tim Gangaware, TNWRRC; and Christopher Wilson, Civil and Environmental Engineering

ISSE researchers are working with the Town of Farragut, Tennessee to identify, locate, and survey the different stormwater structures owned by the town. Along with a visual assessment of the assets' exteriors, a waterproof snake camera was used to inspect the interior of the catch basin inlets, manholes, and culverts. In the end, a GIS map for the Town with all the assets is being compiled along with a detailed report. This inventory and survey are not only required for maintaining the Town's MS4 permits, but also can help Farragut develop a stormwater infrastructure improvement plan.

During this multi-year project, the ISSE team canvased different residential communities in Farragut. In Phase 1, the communities of Village Green, Fox Den, and Kings Gate were surveyed. In Phase 2, the focus was on the Old Stage Hill, Concord Hills, and Thornton Heights communities.

For the assessment, a five-point rating system was used for both the structural soundness and the overall maintenance (i.e., cleanliness) of the assets. In terms of structural soundness, if the asset looked "like new", it received a rating of 1. If the failure or collapse of the asset was imminent it received a rating of 5.

Overall, the assets were in good condition in terms of both structure and maintenance with an average assessment rating of 2. No asset in the six communities received a rating of 5. There were only 21 assets out of the 610 (or 3.5%) that received a 4 in terms of either the maintenance or structural surveys.

Four catch basins received poor maintenance scores due to grass and leaves covering the grates. This blockage can cause rainwater to back-up into the adjacent roadways. Seven open channel drainage-ways suffered from significant siltation. Ten culverts received poor ratings due to deposition blocking the inlets and outlets, causing subsidence. The subsidence is seen as either a distortion of the corrugated pipe or cracks in the frame of the reinforced concrete headwall. The accumulation of the debris in the catchment bay prolongs ponding, increases soil moisture and propagates the subsidence of the surrounding soil of the structure. This differential misalignment is further amplified by traffic over prolonged periods. Potential remedies include catching and removing the debris before it enters the culvert; installing a larger outlet as well as increasing the catchment volume by nearly 25% for future rainfall extremes; and constructing hydraulic vanes to direct debris away from the catchment outlet to lessen the likelihood of outlet blockage.

Methane Center

Protecting and Advancing Water-Energy-Environment and Sustainability (PAWES)

A key goal of the Methane Center for this fiscal year was to select, coordinate, and organize a team of interdisciplinary scientists from across the US to develop the idea and goals for a methane focused NSF Engineering Research Center. We gathered engineers, scientists, and humanists from a variety of institutions via teleconference quarterly in 2018-2019 to begin developing this program. We developed a preproposal for PAWES (Protecting and Advancing Water-Energy-Environment and Sustainability).

The PAWES program is focused on creating a transformative systems approach to optimize water usage in the oil and gas (O&G) industry, minimize chemical use, and increase O&G production, while addressing societal concerns. PAWES will enter the water-energy nexus to meet the technological challenges of unconventional oil and gas and emphasize solutions that address social and environmental issues. Research will incorporate, impact, and challenge the practices, approaches, and opinions of a diverse group of stakeholders. We submitted a preproposal to NSF in December 2018, and while we were not invited to submit a full proposal, we were encouraged to submit for a planning grant, which we did in April 2019.

Documenting and Preserving UT's Architectural Heritage

In 2006, Dr. Tim Ezzell received a $150,000 grant from the Getty Foundation to create the UT Campus Heritage Plan, an inventory and plan for UT's historic assets. Today, Dr. Ezzell continues this work by assessing and documenting historic properties across the UT system. Sites range from the obscure, a small bridge at the Jackson Agresearch Complex, to the well-known, Knoxville's Eugenia Willams House. Buildings are evaluated based on their historical significance, design quality, and workmanship. In many cases, properties are also documented for the UT archives with a large format camera and sheet film.

East Tennessee Clean Fuels

Developing Tennessee's Electric Vehicle Ride-n-Drive EV Experience

With both continued interest by Tennesseans to experience electric vehicles (EVs) and growth in the number and type of EVs that are available for purchase, ETCF started working in early 2018 to find out what makes an excellent Ride-n-Drive program. Through speaking with a number of programs already in operation in the US, most of which were operated by other US DOE Clean Cities programs and their partners, we learned some of the best tips and tricks for developing a program that is high impact and easy to implement. Two critical pieces were providing a short introduction to EVs at the start of the program and allowing attendees to ask

Eugenia Williams House, Knoxville

questions (which frequently spurs other questions), and developing short pre- and post-drive surveys.

With the basics of the program developed by December 2018, we started holding Ride-n-Drive events in the greater Knoxville area. From those first events we learned the importance of limiting the amount of time taken presenting on EVs and to let the starter dialogue build out the conversation, the value of having higher-quality sales representations from nearby dealerships onsite to assist with the events, and the best way to structure the pre- and post-drive surveys to keep them under 10 questions yet still glean critical data that we need to drive the program.

In most cases, the Ride-n-Drives are either setup for a specific business or are held as part of a public event. In the former case, ETCF has been working hard to develop more business-focused Ride-n-Drives because it allows for the full slate of the experience as compared to public events where the presentation is often not possible, and that question-inducing time is critical to bringing an added level of comfort to the EV drivers. So far in 2019, ETCF . Additionally, ETCF has helped the Middle-West Tennessee Clean Fuels Coalition implement this program at their events, and both coalitions are now working to develop Ride-n-Drive events in cities outside Knoxville and Nashville (events are already planned in Chattanooga).

ETCF Creates the Southeastern Corridors Council

As the Federal Highways Administration (FHWA) continues to support the identification and labeling of corridors where alternative fuels are offered, ETCF decided to ramp-up our efforts towards more effective collaboration across southeastern states in 2019. Through discussions in late 2018, ETCF started the “Southeastern Corridors Council” alongside the Alabama Clean Fuels Coalition as a way to have more southeastern states discuss what is going on in their states with signage. The group currently consists of Clean Cities coordinators and other coalition staff in the states that are part of the U.S. DOE Clean Cities Program southeastern region, but adds all of the states that adjoin that region, with 10 states and 17 coalitions participating (see image; Mississippi doesn’t have a DOE Clean Cities Program).

Other than the obvious need to fill-in corridors with more infrastructure to better enable long-distance travel using various alternative fuels, signage is a critical pieces and includes two different types: directional signage that informs an interstate traveler how to get to a station, and identification signage that simple denotes that a stretch of interstate is an (FHWA-blessed) alt-fuel corridor. Each set of signage comes with its own challenges, from developing how the signage will look and determining the best places to post them, to getting state DOT approvals and finding the best pathway for acquiring the needed funds for constructing and installing the signs.

The Council held four webinars during the first half of 2019 to share information about what is going on in our states, and discuss the best ways to collectively develop both types of signage and plans so that each state doesn’t end up creating signage that looks vastly different from other states. During the period, the state of Louisiana decided on their process and corridor identification signage that

would be used across the state, and it differs slightly from what was recommended by FHWA but is still a good example of one way to manage provide this information to motorists (see photo).

Near future Council plans include inviting state DOT and other department representatives that are involved or interested in corridor discussions on to the calls to strengthen the collaborative efforts. Including key contacts within state departments in the Council and being prepared to pull them into higher-order opportunities (e.g., funding programs, disucssions at southeast regional transportation-focused events) will hopefully improve homogeniety of the resulting signage seen across state lines.

FEWSTERN Outreach

FEWSTERN has generated virtual infrastructure that benefits the project goal of establishing an international research coordination network. For example, the FEWSTERN web site connects FEWS researchers within the U.S. and China and also between the two countries. In addition, the project activities triggered the idea for developing a FEWS Information Hub. Currently, this hub is under development by a private partner with assistance of six U.S. undergraduate students. The hub will be available to the public in August 2019. Once established, the webpage will serve as a hub of FEWS information, including FEWS-relevant articles, projects, news, researchers, stakeholders, videos, and companies.

The project has engaged government officials, program managers, and private industry sectors to facilitate perspective exchange and problem analysis. On February 8, 2019, Ms. Xinyu Yang (Minister Counselor for Education, Chinese Embassy in the U.S.) visited the University of Tennessee to discuss the possibility of FEWS training and offered opportunities for U.S. students to visit China for FEWS-relevant activities. To engage stakeholders including local government representatives, the second annual symposium organized a FEWS-relevant facility tour on China's National Water Pollution Control and Treatment Demonstration Project Site 1 (Dispersal rural wastewater treatment project in Luoyang Town) and Site 2 (Eco-farming system in Xueyan Town).

Part of the program was a visit of a local facility that applies innovative technologies for generating energy from municipal solid wastes. The 30 participants (mostly U.S. faculty and students) of the field trip had opportunities to learn the local leader's perspectives on eco-environmental actions and local needs for FEWS technical support. Following the technical program, the last day of the annual symposium offered a cultural tour. Overall, the 3-day symposium successfully addressed FEWSTERN objectives and expanded the scope and depth of interests of U.S. and Chinese scientists in FEWS research collaborations and facilitated the formation of teams.

ETCF Creates Tennessee Alt-fuel School Bus Users Group

During fall 2018, ETCF made significant strides towards ensuring transportation supervisors for school districts and district contractors across Tennessee knew about their options for pursuing VW funding for replacing old diesel school buses. Working in concert with several partners, we were able to reach almost all of the districts across the state to offer information or assistance. As we neared the December 2018 deadline, roughly 20 school districts or contractors engaged ETCF to either assist them in answering questions as they prepared their own proposals or have ETCF write their proposals.

In all, 15 different applicants ended up winning funding, and ETCF helped 13 of those districts along the way. For two of those applicants, ETCF wrote their proposals and will help those districts--Perry County Schools and Bradford Special School District--implement their projects. Another 10 districts partnered to create winning proposals. From these new partnerships and due in part to continued interest from other fleets that are now asking (post VW funding availability) how certain alt-fuel school buses will work in their fleet, ETCF decided to create a Tennessee Alt-fuel School Bus Users Group. The first meeting of the group is planned during the 2019 Tennessee "Sustainable Transportation Forum & Expo" that will be held in Knoxville September 30 through October 2. The purpose of creating this new Users Group is to a) allow elder alt-fuel user fleets to guide new alt-fuel fleets in their quest toward creating successful alt-fuel programs, b) let ETCF provide oversight, guidance and connections to propane providers, bus manufacturers and other technology partners, and c) foster a teamwork approach toward implementing alternative fuels in school bus fleets to reduce the impacts of diesel school buses on our children's health in Tennessee.

Clarksville city administrators, mechanics, and propane vehicle experts examine a propane autogas school bus at Clarksville-Montgomery County School System.


SCHOOL BUS
SCHOOL BUS
09-30

Research Products

Impacts of Research

TNWRRC FY 2018 Information Transfer Program

The major emphasis of the information transfer program during the FY 2018 grant period was on technical publication support, conference planning and development, and improvement in the information transfer network. The primary purpose of the program was to support the objectives of the technical research performed under the FY 2018 Water Resources Research Institute Program.

As an on-going sponsor, the TNWRRC was involved in the planning and implementation of the 27th Tennessee Water Resources Symposium, which was held on April , 2018 at Montgomery Bell State Park in Burns, Tennessee. The goals of the symposium are: (1) to provide a forum for practitioners, regulators, educators and researchers in water resources to exchange ideas and provide technology transfer activities, and (2) to encourage cooperation among the diverse range of water professionals in the state. As with previous symposia, the 27th Symposium was very successful with over 342 attendees and approximately 71 papers and 25 student posters being presented in the two-day period.

TNWRRC was a co-sponsor of the Tennessee Stormwater Association Annual Conference, “10 Years of Shimmering Success”, held on October 15-17, 2018 at Montgomery Bell State Park. Over 268 attendees, including MS4 communities, state and federal government agencies, and engineering consulting companies from across the State participated in the three-day event. The opening keynote speaker was Ed Carter, Executive Director of Tennessee Wildlife Resources Agency. The conference included over 48 presentations, a special Stormwater Utilities workshop and several social networking sessions.

FEWSTERN

Project activity information, including the FEWSTERN conference agenda, participants, abstract, and photos, is available for the public on the FEWSTERN project website (fews.tennessee.edu). A student experience in FEWSTERN is posted online (ag.tennessee.edu/herbert/Documents/Herbert%20Chronicle/China%20essay.pdf).

FEWSTERN project activities have identified a number of critical research needs:

- FEWS-enhanced Agricultural Water Availability: FEWS research could trigger development and adoption of new technologies for water storage and water-saving agricultural practices.
- FEWS-facilitated Adaptation to Environmental Change: Environmental change (e.g., rising temperature, extreme weather conditions, environmental degradation) is a stressor of FEWS sustainability.
- Stakeholders-targeted FEWS Solutions: FEWS involve multiple stakeholders.
- Waste Mitigation-aligned Sustainability of FEWS Nexus: Environmental sustainability includes mitigation and reutilization of waste resources generated during the lifecycle of products.

FEWSTERN has generated virtual infrastructure that benefits the project goal of establishing an international research coordination network. For example, the FEWSTERN web site connects FEWS researchers within the U.S. and China and also between the two countries. The project has engaged government officials, program managers, and private industry sectors to facilitate perspective exchange and problem analysis.

Data Analytics Support for Integrated Earth Model

Progress: The team is currently finalizing the first dataset. The team has collected in situ measurements, a long-term satellite product, reanalysis products, offline land surface model simulations, and coupled earth system model simulations from multiple sources. Using subsets or all of these datasets, the team has tested several merging approaches, including mean, median, optimal weighting, and emergent constraint, and produced merged products for four soil depths (0-10cm, 10-30cm, 30-50cm, 50-100cm) and four time periods (1950-2016, 1950-2010, 1981-2016, 1981-2010). The team is evaluating these merged products using previously set-aside in situ measurements and short-term satellite products that were not used in the merging. The team is also analyzing long-term trends in the merged products. For the second dataset, the team has conducted a preliminary case study by applying machine learning technique on the West Texas Mesonet, and presented the results at the Gordon Research Conference on Catchment Science in 2019/06. The team has also collected factorial

experiments from coupled earth system models for detection and attribution analysis.

Honors & Awards

CEE Professor Joshua Fu received several marks of recognition this year: The Graduate School awarded a Student/Faculty Research award to Fu and his doctoral student Jiani Tan. Also, Dr. Fu received the Graduate Research Mentor of the Year Award from the Graduate Student Senate and Graduate School as well as the Lyman A. Ripperton Environmental Educator Award from the AWMA. Under Dr Fu's supervision, Xinyi Dong received the Postdoctoral Researcher Impact Award from Office of Research and Engagement.

Dr. Jon Hathaway, Assistant Professor, Department of Civil and Environmental Engineering received the Outstanding Faculty Award from the UT Chapter of the Phi Eta Sigma National Honor Society.

TNWRRC Director Dr. John Schwartz is serving on a National Academies of Sciences, Engineering, and Medicine committee to comprehensively evaluate the Watershed Protection Plan for New York City's drinking water supply. Eighteen experts from around the US are serving on this 21- month long assignment.

Henry Goodrich Chair of Excellence Professor, Dr. Thanos Papanicolaou received the 2018 Hans Albert Einstein Award from American Society of Civil Engineers for his research using a concept called "the aerial probability of entrainment," which helps predict how underwater materials will spread.

Whitney Lisenbee, a Civil & Environmental Engineering doctoral candidate in Water Resources Engineering, was one of 100 doctoral students in the US and Canada selected to receive a $15,000 Scholar Award from the P.E.O Sisterhood in 2018.

Students in the UT Department of Civil & Environmental Engineering Spring 2018 Senor Design capstone course received Second Place in the Water/Environmental Division of the Water Environment Federation Student Design Competition. The students' capstone project required implementing stream rehabilitation strategies to stabilize portions of the stream banks along the Alex Haley Farm property in East Tennessee.

Methane Center Director Terry C. Hazen was awarded the Highly Cited Researcher Award by Web of Science in November 2018.

Media Coverage

The Methane Center's annual NSF report was completed and submitted. This grant has currently yielded two accepted peer review publications led by Methane Center post-doc Maria Fernanda Campa, as well as eight oral and poster presentations at national conferences (all undergrad led expect for one led by Dr. Campa).

In addition, this work was highlighted in the public news via coverage by WTAJ TV Central Pennsylvania News (https://tinyurl.com/y48bnljv) on December 7, 2018. This work was also highlighted in the Knoxville News Sentinel, October 16, 2018 https://www.knoxnews.com/story/news/2018/10/16/ut-study-how-does-fracking-affect-east-tennessees-watersupply/1646383002/

This work was also discussed at the Knoxville public library in a discussion about the book *Saudi America: The Truth About Fracking and How it is Changing the World* by Bethany McLean. Link to the podcast: https://www.knoxlib.org/about/news-and-publications/podcasts/books-sandwiched-podcast/frackings-financial-fragility Creating an NSF Engineering Research Center: Protecting and Advancing Water-Energy-Environment and Sustainability.

News Blogs and Releases

ScienceDaily. News Blog. Scientists hit pay dirt with new microbial research technique. June 24, 2019. https://www.sciencedaily.com/releases/2019/06/190624111537.htm.

Brand, S. and M. Chung. News Blog. Scientists hit pay dirt with new microbial research technique. June 24, 2019. AAAS/EurekAlert!. https://www.eurekalert.org/pub_releases/2019-06/dbnl-shp062119.php.

Brand, S. and M. Chung. News Blog. Scientists hit pay dirt with new microbial research technique - A better method for studying microbes in the soil will help scientists understand large-scale environmental cycles. June 24, 2019. SeedQuest. https://www.seedquest.com/news.php?type=news&id_article=107914.

LongRoom News. News Blog. Scientists hit pay dirt with new microbial research technique. June 24, 2019. LongRoom News. https://www.longroom.com/discussion/1535062/scientists-hit-pay-dirt-with-new-microbial-research-technique.

Brand, S. and M. Chung. News Blog. Scientists hit pay dirt with new microbial research technique. June 24, 2019. Phys.Org. https://phys.org/news/2019-06-scientists-dirt-microbial-technique.html.

Brand, S. and M. Chung. News Blog. Scientists hit pay dirt with new microbial research technique. June 24, 2019. Lab Manager. https://www.labmanager.com/news/2019/06/scientists-hit-pay-dirt-with-new-microbial-research-technique#.XRZAvi_MzUI.

DOE Science News Source. News Blog. Scientists hit pay dirt with new microbial research technique. June 21, 2019. Newswise. https://www.newswise.com/doescience/?article_id=714768&returnurl=aHR0cHM6Ly93d3cubmV3c3dpc2UuY29tL2FydGljbGVzL2xpc3Q= .

Goddard, D. UT News. UT Expert Co-Authors Study on Oil Spill Clean Up Safety. April 17, 2019. Catalyst.

Goddard, D. News Blog. News story from Big News Network on Tuesday 16 April 2019. April 17, 2019. Big News Network

Goddard, D. News Blog. Is it safe to use dispersants in oil spill cleanups? April 17, 2019. ANI. https://www.aninews.in/news/science/is-it-safe-to-use-dispersants-in-oil-spill-clean-ups20190416190407/.

Goddard, D. News Blog. Minimal risk associated with the use of dispersants. April 17, 2019. DECCAN Chronicle. https://www.deccanchronicle.com/lifestyle/health-and-wellbeing/170419/minimal-risk-associated-with-the-use-of-dispersants.html

Goddard, D. News Blog. New report examines Oil dispersants did little harm to ocean, academy says ort examines the safety of using dispersants in oil spill clean ups. April 17, 2019. Tennessee Today.

Hazen, T. C., M. F. Campa, and S. Satinover. Invited. Fracking: the Good, Bad, and Ugly. April 16, 2019. Seniors for Creative Learning, O'Connor Senior Center, Knoxville, TN

Goddard, D. News Blog. New report examines the safety of using dispersants in oil spill clean ups. April 16, 2019. News story from Eurasia Review on Tuesday 16 April 2019

Goddard, D. News Blog. New report examines the safety of using dispersants in oil spill clean ups. April 16, 2019. Lab Manager. https://www.labmanager.com/news/2019/04/new-report-examines-safety-of-using-dispersants-in-oil-spill-clean-ups#.XLYFkC3MwQ9

Goddard, D. News Release. New report examines the safety of using dispersants in oil spill clean ups. April 16, 2019. PHYSORG. https://phys.org/news/2019-04-safety-dispersants-oil-ups.html

Goddard, D. News Release. New report examines the safety of using dispersants in oil spill clean ups. April 15, 2019. AAAS. https://www.eurekalert.org/pub_releases/2019-04/uota-nre041519.php.

Goddard, D. Science Blog. New report examines the safety of using dispersants in oil spill clean ups. April 15, 2019. Science Codex. https://www.sciencecodex.com/new-report-examines-safety-using-dispersants-oil-spill-clean-ups-625808.

Brainard, J. Science News in Brief. Oil dispersants did little harm to ocean, academy says. April 13, 2019. Science 362:106.

Lux, T. and T. Baurick. Radio. Coastal News Roundup: Were The Chemicals Used To Clean Up BP Oil Spill Harmful? April 12, 2019. New Orleans Public Radio. https://www.wwno.org/post/coastal-news-roundup-were-chemicals-used-clean-bp-oil-spill-harmful.

Johnson, J. News. Dispersants one of many oil cleanup tools, panel says. April 10, 2019. https://cen.acs.org/environment/Dispersants-one-oil-cleanup-tools/97/i15.

Cornwall, W. News Blog. Do chemicals that disperse oil spills make the problem worse? Probably not, new study finds. April 5, 2019. Science Now. http://www.sciencemag.org/news/2019/04/do-chemicals-disperse-oil-spills-make-problem-worse-probably-not-new-study-finds

The_University_of_Tennessee_Knoxville. UT Home to Several Most Cited Researchers. December 12, 2018. https://news.utk.edu/2018/12/12/ut-home-to-several-most-cited-researchers/

States_News_Service. UT Home to several Most Cited Researchers'. December 12, 2018.

TendersInfo-News (India). United States : Highly Cited Researchers list includes 15 from ORNL. December 4, 2018.

Printed_Electronics_Now. 'Highly Cited Researchers' List Includes 15 From ORNL. December 4, 2018. https://www.printedelectronicsnow.com/contents/view_breaking-news/2018-12-04/highly-cited-researchers-list-includes-15-from-ornl/

ORNL_Review. 'Highly Cited Researchers' List Includes 15 From ORNL. December 3, 2018. https://www.

ornl.gov/news/highly-cited-researchers-list-includes-15-ornl

States_News_Service. ‘Highly Cited Researchers’ List Includes 15 From ORNL. December 3, 2018.

Targeted-News_Service. ‘Highly Cited Researchers’ List Includes 15 From Oak Ridge National Laboratory. December 3, 2018.

News Blog. UT Professor participates in Fracking Research. October 17, 2018. FIRST BELL ASCE. http://asee.bulletinmedia.com/briefing?d=2018-10-17&doctypecode=asee.

Newspaper. UT fracking study to break new ground, may lead to antibiotic-resistant microbes. October 16, 2018. Knox Sentinel. https://www.knoxnews.com/story/news/2018/10/16/ut-study-how-does-fracking-affect-east-tennessees-water-supply/1646383002/

Justin Condon, a graduate teaching assistant in Civil & Environmental Engineering, uses a jet tester to evaluate a stream bank’s erosion potential.

Publications

Absar, SM; Boulay, AM; Campa, MF; Preston, BL; Taylor, A. The Tradeoff Between Water and Carbon Footprints of Barnett Shale Gas. Journal of Cleaner Production. 2018, 197 (1), 47-56

Meir Alkon, Xiaogang He, Aubrey R Paris, Wenying Liao, Thomas Hodson, Niko Wanders, Yaoping Wang. (In Revision, 2019). Water Security Implications of Coal-Fired Power Plants Financed Through China's Belt and Road Initiative. Energy Policy.

A.F. Astner, D.G. Hayes, H.M. O'Neill, B.R. Evans, S.V. Pingali, and V.S. Urban, 2019, Novel Methodology to Form Micro- and Nano-Plastics from Agricultural Plastic Materials and their Dimensional, Thermal, and Chemical Characterization, Science of the Total Environment, 685: 1097-1106 (doi 10.1016/j.scitotenv.2019.06.241)

Q. Bai, Y. Gong, M. Jin*, X. Xu, "Effects of carbon emission reduction on supply chain coordination with vendor-managed deteriorating product inventory," International Journal of Production Economics, 208, 83-99, 2019.

Baldigo, B.P., M.A. Kulp, and J.S. Schwartz. 2018. Response of fish assemblages to acid-base chemistry in streams of the Great Smoky Mountains National Park. Ecological Indicators 88: 465-484. DOI 10.1016/j.ecolind.2018.01.021.

Beattie, RE; Henke, W; Campa, MF; Hazen, TC; McAliley, LR; Campbell, JH. Variation in Microbial Community Structure Correlates with Heavy-Metal Contamination in Soils Decades After Mining Ceased. Soil Biology and Biochemistry. 2018, 126, 57-63.

Beattie, R. E., W. Henke, M. F. Campa, T. C. Hazen, L. R. McAliley, and J. Campbell. 2018. Variation in microbial community structure correlates with heavy-metal contamination in soils within the Tri-State Mining District, Ottawa County, Oklahoma. Soil Biology and Biochemistry 126:57-63. https://doi.org/10.1016/j.soilbio.2018.08.011 (4.926, 1).

Beattie, R. E., W. Henke, M. F. Campa, T. C. Hazen, L. R. McAliley, and J. Campbell. 2018. Variation in microbial community structure correlates with heavy-metal contamination in soils within the Tri-State Mining District, Ottawa County, Oklahoma. Soil Biology and Biochemistry 126:57-63. https://doi.org/10.1016/j.soilbio.2018.08.011 (4.926, 3).

Beegle-Krause, C. J., O. G. Brakstad, C. Stefanakos, R. L. Daae, O. Pelz, Arden Ahnell, and T. C. Hazen. In Press. Modeled Case Studies of Dissolved Oxygen Reduction During Sub Sea Dispersant Injection in the Event of a Response to an Oil Well Blowout. Marine Pollution Bulletin 5/3/19, accepted 8/7/19.

Jeffrey M. Bielicki, Margaret A. Beetstra, Jeffrey B. Kast, Yaoping Wang, Shaohui Tang. (2019). Stakeholder perspectives on sustainability in the food-energy-water nexus. Frontiers in Environmental Science.

Campa, MF; Techtmann, S; Gibson, C; Xiaojuan, Zhu; Patterson, M; Garcia de Matos Amaral, A; Ulrich, N; Campagna, S; Grant, C; Lamendella, R; Hazen, T. Impacts of Glutaraldehyde on Microbial Community Structure and Degradation Potential in Streams Impacted by Hydraulic Fracturing. Environmental Science and Technology. 2018, 52 (10), 5989-5999.

Campa, M. F., S. M. Techtmann, C. Gibson, X. Zhu, Megan Patterson, A. Garcia de Matos Amaral, N. Ulrich, S. R. Campagna, C. J. Grant, R. Lamendella, and T. C. Hazen. 2018. Impacts of Glutaraldehyde on Microbial Community Structure and Degradation Potential in Streams Impacted by Hydraulic Fracturing. Environ. Sci. Technol. 52:5989-5999 DOI:10.1021/acs.est.8b00239. (6.653, 7).

Campa, M. F., S. M. Techtmann, C. Gibson, X. Zhu, Megan Patterson, A. Garcia de Matos Amaral, N. Ulrich, S. R. Campagna, C. J. Grant, R. Lamendella, and T. C. Hazen. 2018. Impacts of Glutaraldehyde on Microbial Community Structure and Degradation Potential in Streams Impacted by Hydraulic Fracturing. Environ. Sci. Technol. 52:5989-5999 DOI: 10.1021/acs.est.8b00239. (6.653, 10).

Campa, M. F., A. K. Wolfe, S. M. Techtmann, A.-M. Harik, and T. C. Hazen. In Press. Unconventional Oil and Gas Energy Systems: An Unidentified Hotspot of Antimicrobial Resistance. Frontiers in Microbiology 5/15/2019

Campa, M. F., S. M. Techtmann, M. P. Ladd, J. Yan, M. Patterson, A. Garcia de Matos Amaral, K. E. Carter, N. Ulrich, C. Grant, R. L. Hettich, Lamendella, and T. C. Hazen. In Press. The effects of the biocide 2-2-dibromo-3-nitrilopropionamide on microbial community structure and degradation potential in streams impacted by hydraulic fracturing activity.

Chen, C., G. Pan, W. Shi, F. Xu, S. M. Techtmann, S. M. Pfiffner, and T. C. Hazen. 2018. Clay Flocculation Effect on Microbial Community Composition in Water and Sediment. Frontiers in Environmental Toxicology 6(60) DOI 10.3389/fenvs.2018.00060. (4.019, 0).

Chen, C., G. Pan, W. Shi, F. Xu, S. M. Techtmann, S. M. Pfiffner, and T. C. Hazen. 2018. Clay Flocculation Effect on Microbial Community Composition in Water and Sediment. Frontiers in Environmental Toxicology 6(60) DOI 10.3389/fenvs.2018.00060. (4.019, 0).

Chen See, JR; Ulrich, N; Nwanosike, H; McLimas, CJ; Tokarev, V; Wright, JR; Campa, MF; Grant, CJ; Hazen, TC; Niles, J; Lamendella, R. Bacterial Biomarkers of Marcellus Shale Activity in Pennsylvania. Frontiers in Microbiology. 2018, 9, 1697.

Chen See J. R., N. Ulrich, H. Nwanosike, C. J. McLimans, V. Tokarev, J. R. Wright, M. F. Campa, C. J. Grant, T. C. Hazen, J. M. Niles, D. Ressler, and R. Lamendella. 2018. Bacterial Biomarkers of Marcellus Shale Activity in Pennsylvania. Frontiers in Microbiology 9: DOI: 10.3389/fmicb.2018.01697 (4.019, 0).

Chen See, J. R., N. Ulrich, H. Nwanosike, C. J. McLimans, V. Tokarev, J. R. Wright, M. F. Campa, C. J. Grant, T. C. Hazen, J. M. Niles, D. Ressler, and R. Lamendella. 2018. Bacterial Biomarkers of Marcellus Shale Activity in Pennsylvania. Frontiers in Microbiology 9: DOI: 10.3389/fmicb.2018.01697 (4.019, 0).

Christensen, G. W., J.-W. Moon, A. M. Veach, J. J. Mosher, A. M. Wymore, J. D. van Nostrand, J. Zhou, T. C. Hazen, A. P. Arkin and D. A. Elias. 2018. Use of in-field bioreactors demonstrate groundwater filtration influences planktonic bacterial community assembly, but not biofilm composition. PloS one 13:e0194663-e0194663. (2.766, 1).

Christensen, G. W., J.-W. Moon, A. M. Veach, J. J. Mosher, A. M. Wymore, J. D. van Nostrand, J. Zhou, T. C. Hazen, A. P. Arkin and D. A. Elias. 2018. Use of in-field bioreactors demonstrate groundwater filtration influences planktonic bacterial community assembly, but not biofilm composition. PloS 13:e0194663-e0194663. (2.766, 2).

T. Cokyasar , M. Jin*, A. Garcia, “Optimization of size and timing of base-salary increases”, The Engineering Economist, 64(2), 97-115, 2019.

Couradeau, E., J. Sasse, D. Goudeau, N. Nath, S. Gibbons, E. Alm, D. Joyner, T. C. Hazen, B. Bowen, R. R. Malmstrom, and T. R. Northen. 2018. Probing the active members of soil microbiomes using BONCAT-FACS-Seq. J. bioRxiv DOI: 10.1101/404087 %J bioRxiv* (NA, 1)

Couradeau, E., J. Sasse, D. Goudeau, N. Nath, S. Gibbons, E. Alm, D. Joyner, T. C. Hazen, B. Bowen, R. R. Malmstrom, and T. R. Northen. 2018. Probing the active fraction of soil microbiomes using BONCAT-FACS-Seq. bioRxiv https://doi.org/10.1101/404087. (NA, 2)

Couradeau, E., J. Sasse, D. Goudeau, N. Nath, T. C. Hazen, B. Bowen, R. Chakraborty, R. R. Malmstrom, and T. R. Northen. 2019. Probing the active fraction of soil microbiomes using BONCAT-FACS-Seq. Nature Communications 10:2770-2770 DOI 10.1038/s41467-019-10542-0. (11.878, 0)

Danso, D., C. Schmeisser, J. Chow, W. Zimmermann, R. Wei, C. Leggewie, X. Li, T. C. Hazen, and W. Streit. 2018. New Insights into the Function and Global Distribution of Polyethylene Terephtalate (Pet) Degrading Bacteria and Enzymes in Marine and Terrestrial Metagenomes. Appl. Environ. Microbiol. doi:10.1128/AEM.02773-17. (3.633, 6)

Danso, D., C. Schmeisser, J. Chow, W. Zimmermann, R. Wei, C. Leggewie, X. Li, T. C. Hazen, and W. Streit. 2018. New Insights into the Function and Global Distribution of Polyethylene Terephtalate (Pet) Degrading Bacteria and Enzymes in Marine and Terrestrial Metagenomes. Appl. Environ. Microbiol. doi:10.1128/AEM.02773-17. (3.633, 12)

Y. Ding and M. Jin*, “Service and Pricing Strategies in Online Retailing under Carbon Emission Regulation,” Journal of Cleaner Production, 217, 85-94, 2019.

Fakhraei, H., C.T. Driscoll, M.A. Kulp, J.R. Renfro, T.F. Blett, P.F. Brewer, and J.S. Schwartz. 2017. Sensitivity and uncertainty analysis of PnET-BGC informing the development of total maximum daily loads of acidity for streams in Great Smoky Mountains National Park. Environmental Modelling and Software 95: 156-167. DOI 10.1016/j.envsoft.2017.06.013.

W. Forbes, J. Mao, Jiafu*, M. Jin*, et al. “Contribution of environmental forcings to US runoff changes for the period 1950-2010”, Environmental Research Letters, 13, 054023, 2018.

Ge, X., B. J. Vaccaro, M. P. Thorgersen, F. L. Poole, II, E. L. Majumder, G. M. Zane, K. De Leon, W. A. Lancaster, J.-W. Moon, K. A. Lowe, C. J. Paradis, D. C. Joyner, F. von Netzer, D. A. Stahl, P. D. Adams, A. P. Arkin, J. D. Wall, T. C. Hazen, and M. W. W. Adams. 2018. Iron- and Aluminum-Induced Depletion of Molybdenum in Acidic Environments Impedes the Nitrogen Cycle. Environ. Microbiol. 21:152-163. DOI:10.1111/1462-2920.14435 (4.974, 0)

Ge, X., B. J. Vaccaro, M. P. Thorgersen, F. L. Poole, II, E. L. Majumder, G. M. Zane, K. De Leon, W. A. Lancaster, J.-W. Moon, K. A. Lowe, C. J. Paradis, D. C. Joyner, F. von Netzer, D. A. Stahl, P. D. Adams, A. P. Arkin, J. D. Wall, T. C. Hazen, and M. W. W. Adams. 2018. Iron- and Aluminum-Induced Depletion of Molybdenum in Acidic Environments Impedes the Nitrogen Cycle. Environ. Microbiol. 21:152-163. DOI:10.1111/1462-2920.14435 (4.974, 0)

National Academies of Sciences E, Medicine. 2019. The Use of Dispersants in Marine Oil Spill Response doi:10.17226/25161. The National Academies Press, Washington, DC. (NA, 0)

Hazen, T. C. 2019. Environmental Systems Biology Approach to Bioremediation. In: Hurst C. (eds) Understanding Terrestrial Microbial Communities. Advances in Environmental Microbiology, vol 6. Springer, Cham. https://doi.org/10.1007/978-3-030-10777-2_4. (NA, 0).

Hazen, T. C. 2018. Lessons from the 2010 Deepwater Horizon Accident in the Gulf of Mexico. Handbook of Hydrocarbon and Lipid Microbiology Series. In: Wilkes H. (eds) Hydrocarbons, Oils and Lipids: Diversity, Origin, Chemistry and Fate. Handbook of Hydrocarbon and Lipid Microbiology. Springer, Cham. https://doi.org/10.1007/978-3-319-54529-5_31-1. (NA, 0).

Hazen, T. C. 2018. In Situ: Groundwater Bioremediation. Handbook of Hydrocarbon and Lipid Microbiology Series. Consequences of Microbial Interaction with Hydrocarbons, Oils and Lipids: Biodegradation and Bioremediation. Springer, Cham. 1-18. DOI: 10.1007/978-3-319-44535-9_11-1. (NA, 11).

Hazen, T. C. 2018. Cometabolic Bioremediation. Handbook of Hydrocarbon and Lipid Microbiology Series. In: Steffan R. (eds) Consequences of Microbial Interactions with Hydrocarbons, Oils, and Lipids: Biodegradation and Bioremediation. Handbook of Hydrocarbon and Lipid Microbiology. Springer, Cham. 1-15. https://doi.org/10.1007/978-3-319-44535-9_5-1 (NA, 32).

Hazen, T. C., and S. M. Techtmann. 2018. Oil Biodegradation in Deep Marine Basins. In: Steffan R. (eds) Consequences of Microbial Interactions with Hydrocarbons, Oils, and Lipids: Biodegradati4n and Bioremediation. Handbook of Hydrocarbon and Lipid Microbiology. 1-18. Springer, Cham https://doi.org/10.1007/978-3-319-44535-9_22-1 (NA, 24)

Hazen, T. C. 2018. Bioremediation. In: Microbiology of the Terrestrial Subsurface (eds) P. Amy and D. Haldeman, p 247-266. CRC Press, Boca Raton. https://doi.org/10.1201/9781351074568. (NA, 36)

Hazen, T.C., and S. M. Techtmann. 2018. Oil Biodegradation in Deep Marine Basins. In: Steffan R. (eds) Consequences of Microbial Interactions with Hydrocarbons, Oils, and Lipids: Biodegradation and Bioremediation. Handbook of Hydrocarbon and Lipid Microbiology. 1-18. Springer, Cham https://doi.org/10.1007/978-3-319-44535-9_22-1 (NA, 0)

Hazen, T. C. 2018. Cometabolic Bioremediation. Handbook of Hydrocarbon and Lipid Microbiology Series. In: Steffan R. (eds) Consequences of Microbial Interactions with Hydrocarbons, Oils, and Lipids: Biodegradation and Bioremediation. Handbook of Hydrocarbon and Lipid Microbiology. Springer, Cham. 1-15. https://doi.org/10.1007/978-3-319-44535-9_5-1 (NA, 0).

Hazen, T. C. 2018. In Situ: Groundwater Bioremediation. Handbook of Hydrocarbon and Lipid Microbiology Series. Consequences of Microbial Interaction with Hydrocarbons, Oils and Lipids: Biodegradation and Bioremediation. Springer, Cham. 1-18. DOI: 10.1007/978-3-319-44535-9_11-1. (NA, 0).

Hazen, T. C. 2018. Lessons from the 2010 Deepwater Horizon Accident in the Gulf of Mexico. Handbook of Hydrocarbon and Lipid Microbiology Series. In: Wilkes H. (eds) Hydrocarbons, Oils and Lipids: Diversity, Origin, Chemistry and Fate. Handbook of Hydrocarbon and Lipid Microbiology. Springer, Cham. https://doi.org/10.1007/978-3-319-54529-5_31-1. (NA, 0).

Hazen, T. C. 2019. Environmental Systems Biology Approach to Bioremediation. In: Hurst C. (eds) Understanding Terrestrial Microbial Communities. Advances in Environmental Microbiology, vol 6. Springer, Cham. https://doi.org/10.1007/978-3-030-10777-2_4. (NA, 0).

K. He, R. Tang, M. Jin*, Y. Cao, and S. Nimbalkar, "Energy modeling and efficiency analysis of aluminum die casting processes," Accepted by Energy Efficiency, 2018. https://doi.org/10.1007/s12053-018-9730-9

He, Z., P. Zhang, L. Wu, A. M. Rocha, Q. Tu, Z. Shi, Y. Qin, J. Wang, D. Curtis, D. Ning, J. D. Van Nostrand, L. Wu, Y. Yang, D. A. Elias, D. B. Watson, M. W. W. Adams, M. W. Fields, E. J. Alm, T. C. Hazen, P. D. Adams, A. P. Arkin, and J. Zhou. 2018. Microbial functional genes predict groundwater contamination and ecosystem functioning. mBio 9:e02435-17. https://doi.org/10.1128/mBio.02435-17. (6.689, 8).

He, Z., P. Zhang, L. Wu, A. M. Rocha, Q. Tu, Z. Shi, Y. Qin, J. Wang, D. Curtis, D. Ning, J. D. Van Nostrand, L. Wu, Y. Yang, D. A. Elias, D. B. Watson, M. W. W. Adams, M. W. Fields, E. J. Alm, T. C. Hazen, P. D. Adams, A. P. Arkin, and J. Zhou. 2018. Microbial functional genes predict groundwater contamination and ecosystem functioning. mBio 9:e02435-17. https://doi.org/10.1128/mBio.02435-17. (6.689, 11).

Hu, W., Q. Nie, B. Huang, S. Su, Y. Du, X. Shu, and Q. He. 2018. Mechanical property and microstructure characteristics of geopolymer stabilized aggregate base. Constr. Build. Mater. 191: 1120-1127. DOI: 10.1016/j.conbuildmat.2018.10.081

Hu, W., Q. Nie, B. Huang, X. Shu, and Q. He. 2018. Mechanical and microstructural characterization of geopolymers derived from red mud and fly ashes. J. Clean. Prod. 186: 799-806. DOI: 10.1016/j.jclepro.2018.03.086

Johnston, E. R.., M. Kim, J. K Hatt, J. R. Phillips, Q. Yao, Y. Song, T. C. Hazen, M. A. Mayes, and K. T. Konstantinidis. 2019. Phosphate addition increases tropical forest soil respiration primarily by deconstraining microbial population growth. Soil Biology and Biochemistry 130:43-54. (4.926, 0)

Johnston, E. R.., M. Kim, J. K Hatt, J. R. Phillips, Q. Yao, Y. Song, T. C. Hazen, M. A. Mayes, and K. T. Konstantinidis. 2019. Phosphate addition increases tropical forest soil respiration primarily by deconstraining microbial population growth. Soil Biology and Biochemistry 130:43-54. doi.org/10.1016/j.soilbio.2018.11.026. (4.926, 0)

P. Kelle*, J. Song, M. Jin, H. Schneider, C. Claypool, "Evaluation of operational and environmental sustainability tradeoffs in multimodal freight transportation planning," International Journal of Production Economics, 209, 411-420, 2019.

Khojandi, A., V. Tansakuly, X. Li, R.S. Koszalinski, W. Paiva. Prediction of Sepsis and In-Hospital Mortality Using Electronic Health Records. Methods of Information in Medicine, 57(04):185-193, 2018.

Khojandi, A., O. Shylo, M. Zokaeinikooy. Automatic EEG Classification: A Path to Smart and Connected Sleep Interventions. Annals of Operations Research, 1-22, 2018.

Khojandi, A., L.M. Maillart, O.A. Prokopyev, M.S. Roberts, S.F. Saba. Dynamic Abandon/Extract Decisions for Failed Cardiac Leads. Management Science, 64(2):633-651, 2018.

Kimbrel, J., N. Ballor, Y. Wu, M. David, T. C. Hazen, B. Simmons, S. Singer, and J. Jansson. 2018. Microbial Community Adaptations to Saline Conditions Along a Hypersalinity Gradient. Frontiers in Microbiology 9:1492 doi: 10.3389/fmicb.2018.01492. (4.019, 2).

Kimbrel, J., N. Ballor, Y. Wu, M. David, T. C. Hazen, B. Simmons, S. Singer, and J. Jansson. 2018. Microbial Community Adaptations to Saline Conditions Along a Hypersalinity Gradient. Frontiers in Microbiology 9:1492 doi: 10.3389/fmicb.2018.01492. (4.019, 0).

Koszalinski, R.S., V. Tansakuly, A. Khojandi, X. Li. Missing Data, Data Cleansing and Treatment from a Primary Study: Implications for Predictive Models. CIN: Computers, Informatics, Nursing, 36(8):367-371, 2018.

Kothari, A. Yu-Wei Wu, J.-M. Chandonia, M. Charrier, L. Rajeev, A. M. Rocha, D. C. Joyner, T. C. Hazen, S. W. Singer, and A. Mukhopadhyay. 2019. Large circular plasmids from groundwater plasmidomes span multiple incompatibility groups and are enriched in multi-metal resistance genes. mBio 10:e02899-18. https://doi.org/10.1128/mBio.02899-18. (6.689, 5).

Kothari, A. Yu-Wei Wu, J.-M. Chandonia, M. Charrier, L. Rajeev, A. M. Rocha, D. C. Joyner, T. C. Hazen, S. W. Singer, and A. Mukhopadhyay. 2019. Large circular plasmids from groundwater plasmidomes span multiple incompatibility groups

and are enriched in multi-metal resistance genes. mBio 10:e02899-18. https://doi.org/10.1128/mBio.02899-18. (6.689, 5).

Lewis, AJ; Campa, MF; Hazen, TC; Borole, AP. Unravelling Biocomplexity of Electroactive Biofilms for Producing Hydrogen from Biomass. Microbial Biotechnology. 2018, 11(1), 84-97.

Lewis, A. J., M. F. Campa, T. C. Hazen, and A. P. Borole. 2018. Unraveling Biocomplexity of Electroactive Biofilms for Producing Hydrogen from Biomass. Microbial Biotechnology DOI: 10.1111/1751-7915.12756. (3.913, 10).

W. Liu, W. Ma, Y. Hu, M. Jin*, K. Li, X. Chang, X. Yu, "Production planning for stochastic manufacturing/remanufacturing system with demand substitution using a hybrid ant colony system algorithm," Journal of Cleaner Production, 213, 999-1010, 2019.

P. Ma, Y. Gong, M. Jin, "Quality Efforts in Medical Supply Chains Considering Patient Benefits," Accepted by European Journal of Operational Research, 2019

Marietou, A., R. Chastain, F. Beulig, A. Scoma, T. C. Hazen, and D. H. Bartlett. 2018. Corrigendum: The Effect of Hydrostatic Pressure on Enrichments of Hydrocarbon Degrading Microbes From the Gulf of Mexico Following the Deepwater Horizon Oil Spill Frontiers in Microbiology 9: (1050). doi:10.3389/fmicb.2018.01050. (4.019, 6).

Marietou, A., R. Chastain, F. Beulig, A. Scoma, T. C. Hazen, and D. H. Bartlett. 2018. The effect of hydrostatic pressure on enrichments of hydrocarbon degrading microbes from the Gulf of Mexico following the Deepwater Horizon oil spill. Frontiers in Microbiology 9: DOI:10.389/fmcb.2018.00808. (4.019, 1).

Marietou, A., R. Chastain, F. Beulig, A. Scoma, T. C. Hazen, and D. H. Bartlett. 2018. The effect of hydrostatic pressure on enrichments of hydrocarbon degrading microbes from the Gulf of Mexico following the Deepwater Horizon oil spill. Frontiers in Microbiology 9: DOI:10.389/fmcb.2018.00808 04/11/18. (4.019, 0).

Marietou, A., R. Chastain, F. Beulig, A. Scoma, T. C. Hazen, and D. H. Bartlett. 2018. Corrigendum: The Effect of Hydrostatic Pressure on Enrichments of Hydrocarbon Degrading Microbes From the Gulf of Mexico Following the Deepwater Horizon Oil Spill Frontiers in Microbiology 9: (1050). doi:10.3389/fmicb.2018.01050. (4.019, 0).

Miller, J. I., S. M. Techtmann, J. Fortney, N. Mahmoudi, D. Joyner, J. Liu, S. Olesen, E. Alm, A. Fernandez, P. Gardinali, N. GaraJayeva, F. S. Askerov, and T. C. Hazen. 2019. Oil Hydrocarbon Degradation by Caspian Sea Microbial Communities. Front. Microbiol. 10:995. Doi: 10.3389/fmicb.2019.00995. (4.019, 0)

Miller, J. I., S. M. Techtmann, J. Fortney, N. Mahmoudi, D. Joyner, J. Liu, S. Olesen, E. Alm, A. Fernandez, P. Gardinali, N. GaraJayeva, F. S. Askerov, and T. C. Hazen. 2019. Oil Hydrocarbon Degradation by Caspian Sea Microbial Communities. Front. Microbiol. 10:995. Doi: 10.3389/fmicb.2019.00995. (4.019, 0)

Moon, J.-W., C. J. Paradis, D. C. Joyner, F. von Netzer, E. L. Majumder, E. Dixon, M. Podar, G. Xiaoxuan, P. J. Walian, H. J. Smith, X. Wu, G. M. Zane, K. S. Walker, M. P. Thorgersen, F. L. Poole II, L. Lui, B. G. Adams, K. B. De León, S. S. Brewer, D. E. Williams, K. A. Lowe, M. Rodriguez, Jr., T. L. Mehlhorn, S. M. Pfiffner, R. Chakraborty, A. P. Arkin, J. D. Wall, M. W. Fields, M. W. W. Adams, D. A. Stahl, D. A. Elias and T. C. Hazen. 2019. Integrated characterization of subsurface media from locations up- and down-gradient of a uranium-contaminated aquifer J. bioRxiv DOI: dx.doi.org/10.1101/712562

Nie, Q., W. Hu, B. Huang, X. Shu, and Q. He. 2019. Synergistic utilization of red mud for flue-gas desulfurization and fly ash-based geopolymer preparation. J. Hazard. Mater. 369: 503-511. DOI: 10.1016/j.jhazmat.2019.02.059

J.B. Oliveira, M. Jin, R.S. Lima, J.E. Kobza, J.A.B Montevechi, "The role of simulation and optimization methods in supply chain risk management: performance and review standpoints," Simulation Modelling Practice and Theory, 92, 17-44, 2019.

Paradis, C. J., E. R. Dixon, L. M. Lui, A. P. Arkin, J. C. Parker, J. D. Istok, E. Perfect, L. D. McKay, and T. C. Hazen. 2019. Improved method for estimating reaction rates during push-pull tests. Groundwater https://doi.org/10.1111/gwat.12770. (1.900, 2)

Paradis, C. J., L. D. McKay, E. Perfect, J. D. Istok, and T. C. Hazen. 2019. Correction: Push-pull tests for estimating effective porosity: expanded analytical solution and in situ application Hydrogeology Journal 27:437–439. DOI 10.1007/s10040-018-1879-y. (2.071, 0)

Paradis, C. J., J.-W. Moon, D. A. Elias, L. D. McKay, and T. C. Hazen. 2018. In situ decay of polyfluorinated benzoic acids under anaerobic conditions. Journal of Contaminant Hydrology https://doi.org/10.1016/j.jconhyd.2018.08.009 (2.284, 0)

Paradis, C. J., L. D. McKay, E. Perfect, J. D. Istok, and T. C. Hazen. 2018. Push-pull tests for estimating effective porosity: expanded analytical solution and in situ application. Hydrogeology Journal 26:381–393. DOI 10.1007/s10040-017-1672-3. (2.071, 3)

Paradis, C. J., J.-W. Moon, D. A. Elias, L. D. McKay, and T. C. Hazen. 2018. In situ decay of polyfluorinated benzoic acids under anaerobic conditions. Journal of Contaminant Hydrology https://doi.org/10.1016/j.jconhyd.2018.08.009 (2.284, 0).

Paradis, C. J., L. D. McKay, E. Perfect, J. D. Istok, and T. C. Hazen. 2019. Correction: Push-pull tests for estimating effective porosity: expanded analytical solution and in situ application Hydrogeology Journal 27:437–439. DOI 10.1007/s10040-018-1879-y. (2.071,0).

Paradis, C. J., E. R. Dixon, L. M. Lui, A. P. Arkin, J. C. Parker, J. D. Istok, E. Perfect, L. D. McKay, and T. C. Hazen. 2019. Improved method for estimating reaction rates during push-pull tests. Groundwater doi:10.1111/gwat.12770. (1.900, 2)

Ramshani, M., A. Khojandi, X. Li, O. Omitaomu. Optimal Planning of the Joint Placement of Photovoltaic Panels and Green Roofs Under Climate Change Uncertainty, Omega: The International Journal of Management Science, 2018 (forthcoming).

Ramdhani, R.A., A. Khojandi, O. Shylo, B.H. Kopell. Optimizing Clinical Assessments in Parkinson's Disease Through the Use of Wearable Sensors and Data Driven Modeling. Frontiers In Computational Neuroscience, 12:72, 2018.

Ribicic, D., R. Netzer, T. C. Hazen, S. M. Techtmann, F. Drabløs, and O. Brakstad. 2018. Microbial community and metagenome dynamics during biodegradation of dispersed oil in cold seawater reveals potential key-players. Marine Pollution Bulletin 129:370-378. (3.241, 4).

Ribicic, D., R. Netzer, T. C. Hazen, S. M. Techtmann, F. Drabløs, and O. Brakstad. 2018. Microbial community and metagenome dynamics during biodegradation of dispersed oil in cold seawater reveals potential key-players. Marine Pollution Bulletin 129:370-378. (3.241, 4).

Smith, H. J., A. J. Zelaya, K. B. De León, R. Chakraborty, D. A. Elias, T. C. Hazen, A.P. Arkin, A.B. Cunningham and M. W. Fields. 2018. Flow and Mixing Zones in the Shallow, Terrestrial Subsurface: Potential Effects on Biofilm Dynamics. FEMS Microbiology Ecology 94(12):16 fiy191, https://doi.org/10.1093/femsec/fiy191 (3.495, 1)

Smith, H. J., A. J. Zelaya, K. B. De León, R. Chakraborty, D. A. Elias, T. C. Hazen, A.P. Arkin, A.B. Cunningham and M. W. Fields. 2018. Flow and Mixing Zones in the Shallow, Terrestrial Subsurface: Potential Effects on Biofilm Dynamics. FEMS Microbiology Ecology 94(12):16 fiy191, https://doi.org/10.1093/femsec/fiy191 (3.495, 2)

Tirpak, R.A., J.M. Hathaway, J.A. Franklin, A. Khojandi. The Health of Trees in Bioretention: A Survey and Analysis of Influential Variables. Journal of Sustainable Water in the Built Environment, 4(4):04018011, 2018.

R. Andrew Tirpaka, Jon M.Hathaway, Jennifer A.Franklin, Eric Kuehler, 2019. Suspended pavement systems as opportunities for subsurface bioretention. Ecological Engineering, 134: 39-46 (https://doi.org/10.1016/j.ecoleng.2019.05.006)

Ulrich, K; Kirchner, V; Drucker, R; Wright, J; McLimas, C; Hazen, T; Campa, MF; Grant, C; Lamendella, R. Response of Aquatic Bacterial Communities to Hydraulic Fracturing in Northwestern Pennsylvania: A Five-Year Study. Scientific Report. 2018, 8 (1) 5683.

Ulrich, N., V. Kirchner, R. Drucker, J. Wright, C. McLimans, T. C. Hazen, M. F. Campa, C. Grant, and G. Lamendella. 2018. Response of Aquatic Bacterial Communities to Hydraulic Fracturing in Northwestern Pennsylvania: A Five-Year Study. Nature Scientific Reports 8, 5683-5683. (4.122, 2).

Ulrich, N., V. Kirchner, R. Drucker, J. Wright, C. McLimans, T. C. Hazen, M. F. Campa, C. Grant, and G. Lamendella. 2018. Response of Aquatic Bacterial Communities to Hydraulic Fracturing in Northwestern Pennsylvania: A Five-Year Study. Nature Scientific Reports 8: 5683-5683. (4.122, 5).

van Wyk, F., Y. Wang, A. Khojandi, N. Masoud. Real-Time Sensor Anomaly Detection and Identification in Automated Vehicles, IEEE Transactions on Intelligent Transportation Systems, 2019, (forthcoming).

van Wyk, F., A. Khojandi, R. Kamaleswaran. Improving Prediction Performance Using Hierarchical Analysis of Real-Time Data: A Sepsis Case Study, IEEE Journal of Biomedical and Health Informatics, 23(3): 978-986, 2019.

van Wyk, F., A. Khojandi, A. Mohammad, E. Begoli, R.L. Davis, R. Kamaleswaran. A Minimal Set of Physiomarkers in Continuous High Frequency Data Streams Predict Adult Sepsis Onset Earlier, International Journal of Medical Informatics, 122:55-62, 2019.

van Wyk, F., A. Khojandi, B. Williams, D. MacMillan, R.L. Davis, D. Jacobson, R. Kamaleswaran. A Cost-Benet Analysis of Automated Physiological Data Acquisition Systems Using Data-Driven Modeling. Journal of Healthcare Informatics Research, 1-19, 2018.

D, Vance, S. Nimbalkar*, A. Thekdi, K. Armstrong, T. Wenning, J. Cresko, M. Jin, "Estimation of and Barriers to Waste Heat Recovery from Harsh Environments in Industrial Processes," Journal of Cleaner Production, 222, 539-549, 2019.

Adriano Vinca, Simon Parkinson, Edward Byers, Peter Burek, Zarrar Khan, Volker Krey, Fabio A. Diuana, Yaoping Wang, Ansir Ilyas, Alexandre C. Köberle, Iain Staffel, Stefan Pfenninger, Abubakr Muhammad, Andrew Rowe, Roberto Schaeffer, Narasimha D. Rao, Yoshihide Wada, Ned Dhilali, and Keywan Riahi. The Nexus Solutions Tool (NEST): An open platform for optimizing multi-scale energy-water-land system transformations. Geoscientific Model Development, 12, 677-698, 2019. (https://doi.org/10.5194/gmd-12-677-2019)

Y. Wang*, Z. Yu, M. Jin, "E-commerce supply chains under capital constraints," Electronic Commerce Research and Applications, 35, 2019.

Mengru Wang, Ting Tang, Peter Burek, Petr Havlik, Tamas Krisztin, Carolien Kroeze, David Leclere, Maryna Strokal, Yoshihide Wada, Yaoping Wang, Simon Langan. (In Revision, 2019). Increasing nitrogen export by the Indus river. Science of the Total Environment.

Wei, H., J. Shi, X. Yang, J. Wang, K. Li, and Q. He. 2018. CCl4-enhanced ultrasonic irradiation for ciprofloxacin degradation and antibiotic activity. Water Environ. Res. 90(7): 579-588. DOI: 10.2175/106143017X15131012153077

Wilt, C., T. Ezzell, E. Wittenburg. 2018. Hurdles to Healthcare Overcoming Health Access Barriers in Haywood County, Tennessee, Report prepared for Haywood County, Tennessee.

Woo, H. L. and T. C. Hazen. 2018. Enrichment of bacteria from Eastern Mediterranean Sea involved in lignin degradation via the phenylacetyl-CoA pathway. Frontiers in Aquatic Microbiology doi: 10.3389/fmicb.2018.00922. (4.019, 1).

Woo, H. L. and T. C. Hazen. 2018. Enrichment of bacteria from Eastern Mediterranean Sea involved in lignin degradation via the phenylacetyl-CoA pathway. Frontiers in Aquatic Microbiology doi: 10.3389/fmicb.2018.00922. (4.019, 0).

Wu, X., L. Wu, Y. Liu, P. Zhang, Q. Li, J. Zhou, N. Hess, T. C. Hazen, and R. Chakraborty. 2018. Microbial interactions with dissolved organic matter drive carbon dynamics and community succession in groundwater. Frontiers in Microbiology doi: 10.3389/fmicb.2018.01234. (4.019, 5).

Wu, X., L. Wu, Y. Liu, P. Zhang, Q. Li, J. Zhou, N. Hess, T. C. Hazen, and R. Chakraborty. 2018. Microbial interactions with dissolved organic matter drive carbon dynamics and community succession in groundwater. Frontiers in Microbiology doi: 10.3389/fmicb.2018.01234. (4.019, 0).

Wu, L., D. Ning, B. Zhang, Y. Li, Q. He, et al. 2019. Global diversity and biogeography of bacterial communities in wastewater treatment plants. Nat. Microbiol. DOI: 10.1038/s41564-019-0426-5

F. Xie, N. Liu, M. Jin, Z. Liu*, "Impacts of the Consumer Heterogeneity in Fuel Economy Valuation on Compliance with Fuel Economy Standards", Energy, 177, 167-174, 2019.

Yang, T., L. Sheng, Y. Wang, K. N. Wyckoff, C He, and Q. He. 2018. Characteristics of cadmium sorption by heat-activated red mud in aqueous solution. Sci. Rep. 8: 13558. DOI: 10.1038/s41598-018-31967-5

Yang, X.-Y., H. Wei, K.-B. Li, Q. He, J.-C. Xie, and J.-T. Zhang. 2018. Iodine-enhanced ultrasound degradation of sulfamethazine in water. Ultrason. Sonochem. 42: 759-767. DOI: 10.1016/j.ultsonch.2017.12.045

Yang, T., Q. He, C. He, A. Wang, and L. Sheng. 2018. Effect of planting and fertilization on lead partitioning in dredged sediment. Ecotoxicology 27(1): 69-80. DOI: 10.1007/s10646-017-1871-7

Yao, Q, Z. Li, Y. Song, S. J. Wright, X, Guo, A. Biswas, S. G. Tringe, T. C. Hazen, B. L. Turner, M. Mayes, and C. Pan. 2018. Community Proteogenomics Reveals the Systemic Impact of Phosphorus Availability on Microbial Functions in Tropical Soil. Nature Ecology and Evolution 1-11. (NA, 8)

Young, B. N., J. M. Hathaway, W. A. Lisenbee, and Q. He. 2018. Assessing the runoff reduction potential of highway swales and WinSLAMM as a predictive tool. Sustainability 10(8): 2871. DOI: 10.3390/su10082871

Zelaya, A. J., A. E. Parker, K. L. Bailey, P. Zhang , J. Van Nostrand, N. Daliang, D. A. Elias, J. Zhou, T. C. Hazen, and M. W. Fields. 2019. High spatiotemporal variability of bacterial diversity over short time scales with unique geohydrochemistry associations within a shallow, pristine aquifer. Water Research 164:114917. doi.org/10.1016/j.watres.2019.114917

TNWRRC Conference Proceedings

2017TN129B – Evaluation of Fecal Indicators and Pathogens at Recreational Beaches in Central Tennessee. Conference Proceedings: Todd A.C., J. Jatko, D. Chan, M. Stallard and F. Bailey, 2018, Presence of Fecal Bacteria and Associated Pathogens at Recreational Freshwater Beaches in Tennessee, USA, “in” Proceedings 39th Annual meeting of the Society of Environmental Toxicology and Chemistry. Sacramento, CA. November 4-8, 2018.

2017TN129B – Evaluation of Fecal Indicators and Pathogens at Recreational Beaches in Central Tennessee. Stallard, Megan, 2019. Factors that Influence the Presence of Fecal Indicator Bacteria from Three Potential Exposure Pathways, “PhD Dissertation” Department of Biology and Molecular Biosciences, Middle Tennessee State University, Murfreesboro, TN. pp. 158.

2017TN132B – Examining Sediment Rating Curves Hysteresis with State-of-the-Art Sensors. Conference Proceedings: Wyssmann, M.A., A.N. Papanicolaou, T. Kyriakopoulos,2018. Particle resting times: Modeling the role of turbulence. In Proceedings of the American Geophysical Union Fall Meeting. Washington, D.C., December 10-14, 2018.

2017TN133B - Field study of Spatiotemporal Variability in Bedload Transport in Mountainous Boulder Arrayed Streams for Development of a Mechanistic Model. Articles in Refereed Scientific Journals: Papanicolaou, A.N., A.G. Tsakiris, M.A. Wyssmann, and C.M. Kramer. 2018. Boulder Array Effects on Bedload Pulse and Depositional Patches. Journal of Geophysical Research: Earth Surface, 123. DOI:10.1029/2018JF004753.

2017TN133B - Field study of Spatiotemporal Variability in Bedload Transport in Mountainous Boulder Arrayed Streams for Development of a Mechanistic Model. Conference Proceedings: Wyssmann, M.A., and Papanicolaou, A.N. 2018. Lagrangian Modeling of Bedload Movement via the Impulse Entrainment Method. In Proceedings River Flow 2018, EDP Sciences, 0541,doi:10.1051/e3sconf/20184005041.

2018TN136B – Three-Dimensional Modeling of River Flows Under Extreme Weather Scenarios. Other Publications: Roy, S.,J.R. Bathi.2019, Decision Supporting Hydrodynamic Modeling of Tennessee River, 28th Tennessee Water Resources Symposium, Tennessee Section of the American Water Resources Association, Nashville, TN. April 10-12, 2019 (Poster).

2018TN136B – Three-Dimensional Modeling of River Flows Under Extreme Weather Scenarios. Conference Proceedings: Bathi, J.R., S. Tareq, S. Palchoudary, 2019, Detection and Treatability of Nanomaterial in Surface Waters, In Proceedings of the 28th Tennessee Water Resources Symposium, Tennessee Section of the American Water Resources Association, Nashville, TN. pp. 8A41-45.

2018TN135B – Low-cost Real-time Streamflow Network for Falling Water River Watershed. Conference Proceedings: Kalyanapu, A.J., A. Davis. 2019, Developing an Early Warning System for Floods for Window Cliffs State Natural Area, Putnam County, Tennessee, In Proceedings of the 28th Tennessee Water Resources Symposium, Tennessee Section of the American Water Resources Association, Nashville, TN. pp. 5C 13-17.

Future Goals

Director's Goals for 2019-20

ISSE will continue to implement its five-year strategic plan to increase the research, educational, and outreach activities at the University of Tennessee, including both the University of Tennessee, Knoxville and UT Institute of Agriculture. ISSE will promote the development of policies, technologies, and educational programs that will address and help remedy critical environmental and security issues around the world.

As a State Center of Excellence, ISSE will expand its outreach, education, and applied research for the State of Tennessee and increase our engagement with state agencies such as TDEC, TDOT, and TDA; with municipal and county local governments; and with local industries such as TVA and Bush Brothers. ISSE will also improve the economic and environmental sustainability of the Appalachian area.

ISSE will continue funding seed grant proposals and strategically supporting six or seven key affiliated faculty members annually. The funding will be concentrated around the themes of natural and built systems sustainability that focus on the food, energy, and water nexus. The seed grants and strategic investment will emphasize societal impacts and promote externally funded research. ISSE will grow as an interdisciplinary platform to help faculty and research staff pursue larger grants and facilitate more collaboration with the Oak Ridge National Laboratory. ISSE will continue its supports of graduate and undergraduate students to prepare a quality workforce that can handle our national environmental issues.

ISSE will continue supporting the new initiative with UTIA to grow an international Research Coordination Network (iRCN) around environmental sustainability. The network will provide a global platform to tackle environmental issues faces by many countries: global climate change, water stress, and urbanization.

Following are the 2019–20 plans for the centers housed within ISSE.

TNWRRC

TNWRRC has set 10 goals for 2019-20. In research, we aim to fund 104b grants as seed projects that will align with the NIWR/USGS 10-year vision statement and hold the greatest promise for advancing a funded research area. We will promote and assist state researchers in submitting USGS 104g proposals, and working with the Watershed Faculty Consortium, we will assist in building research teams for proposals. TNWRRC will work with the Tennessee Department of Agriculture on several projects related to bank stability and sediment impairment and another related to nutrient monitoring. We will finalize the MOA with the USEPA for the Watershed Center of Excellence and, with TDEC and TDA, assist in research for improving watershed management strategies and for researchers and watershed groups to obtain 319 grants.

In the area of outreach, TNWRRC will engage with the major state metro areas with NPDES municipal stormwater permits, and develop an urban waters report card to assess the water quality and ecological health of streams. We will expand the professional training courses and webinars offered through TNWRRC. Working with the Watershed Faculty Consortium, TNWRRC will organize the annual Watershed Symposium to be held in September 2020, with climate change as the theme.

Our goals for education include having UT's Watershed Faculty Consortium update the undergraduate and graduate level Watershed Minors. Plans are underway to collaborate with the Tennessee Tech Water Center to host a state-wide "student science day" and poster competition.

Appalachian Tourism

Because diversity is a challenge for many areas, this year's ATP class is exploring barriers to minority participation in outdoor recreation. While minority tourism is one of the fastest growing segments of the tourism industry, African-Americans comprise just one percent of visitors to the Region. Minorities are also underrepresented in the tourism industry, especially in leadership positions. As the traveling public becomes more diverse, Appalachian communities must learn to become welcoming places for all visitors.

Appalachian Community Technical Assistance and Training Program (ACTAT)

ISSE researchers, by working with Tennessee Department of Environment & Conservation, have targeted eight utilities to enlist for the first two Workshop-In-A-Box training sessions. The first

training session is planned for September 6, 2019 in Johnson City, TN.

Methane Center

For the coming year the Methane Center will continue its goal to form a transdisciplinary-multi institution NSF Engineering Research Center. We will continue to gather data and publish in various methane related research topics to strengthen our understanding and leadership in the field.

Integrated Earth Model

The team will finalize the first dataset and submit a journal paper during the next several months. During the next academic year, the team will conduct detection and attribution analysis based on the merged product and the collected factorial experiments. The team will also implement the tested machine learning technique globally for producing the second dataset. The team will also submit proposals for potential future expansion of this project to funding agencies such as Department of Energy.

FEWSTERN

FEWSTERN will organize its third annual symposium in Seattle on October 26-29, 2019. The symposium aims to exchange innovations, share ongoing research, and explore new research and partnerships with industry, government leaders, and non-profit organizations. The format of the symposium will emphasize panel presentations, poster sessions, and roundtable discussions designed to optimize

networking opportunities and encourage collaboration. Attendees will work face-to-face to develop grant proposals, integrate and narrow research plans, and interact across research groups.

The FEWSTERN team plans to submit a proposal to NSF in Fall 2019 to promote a FEWS-centered environmental sustainability research agenda that informs at various scales of the environmental consequences of actions or inactions. The objectives are to (1) build an iRCN that encompasses multi-stakeholder communication and feedback, (2) develop a multinational focus of research teams able to collaborate and communicate without boundaries or borders, (3) expand and improve transdisciplinary collaboration, (4) provide a focus for nurturing the next generation workforce, (5) create platforms to inspire community outreach and strengthen community engagement, and (6) embrace a new level of Network–to-Network synergy and interaction.

ETCF Coalition Goals

East Tennessee Clean Fuels plans to increase its total gasoline-gallon equivalents of alt fuels consumed in the eastern half of Tennessee and increase fuel displacement by 17 percent. To develop alt fuel users and supporting infrastructure, we plan to build four public E85 or B20 stations, two public or private compressed natural gas stations, three public or private propane autogas stations, and two DC fast-charging stations. ETCF intends to reach 10 new fleets and clients interested in converting to alt fuels, host about a dozen electric vehicle Ride n' Drive events across the state, and organize 6-10 educational tours of fleet facilities, infrastructure, and other alt-fuels related facilities.

Notes

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INSTITUTE FOR A SECURE & SUSTAINABLE ENVIRONMENT

311 Conference Center Building • Knoxville, Tennessee 37996-4134 • isse@utk.edu • 865.974.4251 • isse.utk.edu